NUCLEAR AND NBC CONTAMINATION SURVIVABILITY OF MEDICAL MATERIEL

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The purpose of this paper ~~is to~~ provides military personnel and contractors involved in the development and acquisition of military equipment with background information pertaining to Nuclear, Biological, and Chemical (NBC) contamination survivability. Two categories of threat environments identified as Nuclear Weapons Effects (NWE) and NBC contamination are thoroughly described as well as the NBC terminology, protective measures, engineering practices, and organizational responsibilities that must be considered during materiel acquisition. The content in this paper was consolidated from the vast number of military standards (MIL-STDs), data item descriptions (DIDs), Army regulations (ARs), Quadripartite Standardization Agreements (QSTAGs) and other military documents that concern nuclear and NBC contamination and survivability as well as the input of the U.S. Army Nuclear and Chemical Agency, U.S. Army Laboratory Command and the U.S. Army Chemical Research, Development, and Engineering Center. Keywords.

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NUCLEAR AND NBC CONTAMINATION
SURVIVABILITY OF MEDICAL MATERIEL

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APPENDICES

SECTION 1. INTRODUCTION

1.1 Capabilities of potential threat nations to wage warfare through the use of nuclear, biological, and chemical weapons pose special considerations for Combat Developers (CBTDEVs) in the U. S. Army Training and Doctrine Command (TRADOC) and their counterparts, Army Materiel Command (AMC) Materiel Developer's (MATDEVs). These considerations are also applicable to agencies outside of TRADOC and AMC who have CBTDEV and MATDEV responsibilities. This includes the Academy of Health Sciences who perform CBTDEV functions for the U.S. Army Health Services Command and agencies such as the Chief of Engineers, The Surgeon General, the U.S. Army Information Systems Command, and the Strategic Defense Command who all have MATDEV responsibilities. Since there is a finite possibility for use of these types of weapons in future conflicts, it is essential that Army materiel and personnel be capable of surviving the effects of such weapons. To ensure that survivable equipment is provided for the combat soldier, the Army has in place regulations, procedures, and specialized technical agencies and teams. Army Regulation (AR) 70-60 "Nuclear Survivability of Army Materiel" establishes the policies and procedures that outline the Army's effort to field mission-essential materiel that is nuclear survivable. AR 70-71 "Nuclear, Biological, and Chemical Contamination Survivability of Army Materiel," is the counterpart to AR 70-60 and deals with the policies and procedures that govern Army efforts in developing mission-essential materiel that can survive the contaminating effects of chemical/biological agent warfare and residual nuclear radiation, and the effects of decontamination.

1.2 This document is concerned with the development and acquisition of survivable Army equipment and protective measures against two categories of threat environments identified as Nuclear Weapons Effects (NWE) and Nuclear, Biological, and Chemical (NBC) Contamination. NWE are caused by the detonation of a nuclear weapon and consist of four types of environments which impact a target within a period of one minute. These are the electromagnetic pulse (EMP), initial nuclear radiation (INR), thermal radiation, and blast. For long periods following the first minute, a nuclear weapon detonation creates radioactive particles which are dispersed in the atmosphere and can contaminate areas through processes termed fallout and rainout. In addition, long term gamma activity in the material of Army equipment is created by the interaction of initial radiation (neutrons) with that material. The fallout/rainout environment and the residual gamma activity in materials constitute the nuclear portion of the NBC contamination category of threat environments. The biological portion of NBC consists of micro-organisms and toxins which includes bacteria, rickettsia, viruses, fungi, and microbial toxins. The chemical portion include blood agents (such as cyanide), nerve agents (such as VX, GB, or thickened GD), and blister agents (such as mustard). At this point, it is important to emphasize the distinction drawn, by the Army, between NWE and the nuclear portion of NBC contamination. To reiterate, NWE are the effects that result in the first minute following a nuclear detonation (EMP, INR, thermal radiation and blast), which subside in this first minute. However, the INR interacts with the surroundings and creates a radiation hazard (residual gamma activity, fallout, and rainout) that exists long after the initial detonation. This residual nuclear radiation (RNR) environment is characteristically different from the INR condition and is handled through other techniques (under the category of NBC contamination). When appropriate, the term "NWE" will from here on, be referred to as "nuclear" to be consistent with the terminology used in AR 70-60 and other Army publications.

SECTION 2. SURVIVABILITY

2.1 Survivability is the capability of a system to be subjected to a threat environment and still accomplish its designated mission. This does not mean that the system must retain all of its designed capability. That is, even though the system functions at a reduced performance level, it still may perform at or above a minimum level which is acceptable to the user which may be referred to as the survivability criteria. It is the responsibility of the CBTDEV to determine this minimal functional performance requirement, so that the MATDEV knows the performance level to which the equipment is to be designed and developed.

2.1.1 There are several methods available for achieving nuclear survivability which include proliferation, redundancy, mitigation, avoidance, reconstitution, and hardening (see Glossary, p. C-5). Any combination of two or more of these methods might be utilized to achieve the most cost-effective approach.

2.1.2 NBC contamination survivability is the ability of a system to withstand an NBC contaminated environment and to be capable of withstanding decontamination procedures without losing the ability to complete the assigned mission. NBC contamination survivability is comprised of three characteristics: (1) decontaminability, (2) hardness, and (3) compatibility. Decontaminability is the ability of a system to be decontaminated to reduce the hazard to a negligible level for persons who operate, maintain, and resupply the materiel. NBC hardness is that level of ability of a system to withstand the materiel damaging effects of both NBC contamination and the procedures and agents required for decontamination. Compatibility is that level of ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC protective ensemble. Collective protection equipment (CPE) does not provide compatibility but CPE may be substituted for compatibility. In contrast to nuclear survivability, neither redundancy nor resupply is a completely acceptable alternative for achieving NBC contamination survivability since redundant and resupplied systems would likely be contaminated along with the units they would replace.

SECTION 3. ESTABLISHMENT OF NUCLEAR HARDENING AND NBC CONTAMINATION SURVIVABILITY CRITERIA

3.1 Operational and Organizational (O&O) Plan:

The process for the establishment of survivability criteria begins in a preliminary phase of the equipment acquisition process and is the responsibility of the CBTDEV. This phase involves the performance of an analysis (mission area analysis) from which deficiencies in available hardware capabilities are identified. It is at that point that the requirement for nuclear and/or NBC contamination survivabilities for the envisioned equipment is determined. In that phase, the CBTDEV develops an Operational and Organizational (O&O) Plan within which is stated if the new equipment is mission essential and if the threat includes nuclear weapons and/or biological and chemical warfare agents. If the equipment is mission essential and the threat includes nuclear and or chemical and biological weapons, then the O&O Plan shall declare that nuclear and/or NBC contamination survivability are to be included in the development of the new system's performance requirements.

3.2 Concept Formulation Package (CFP):

The Concept Exploration (CE) Phase initiates the acquisition process. During the CE Phase, a document referred to as the Concept Formulation Package (CFP) is developed. The CFP summarizes the results of efforts conducted in the CE phase and establishes the technical and economic specifications for a product. The CFP consists of four documents: 1) Trade-Off Analysis, 2) Trade-Off Determination, 3) Best Technical Approach, and 4) Cost Effectiveness Analysis or Abbreviated Analysis. It is the MATDEV who assesses performance, cost, schedule, and risk for each possible approach in a trade-off analysis. The CBTDEV evaluates results and performs another trade-off analysis from the user's, trainer's, and logistician's viewpoint. Then, jointly, they document the best technical approach which includes nuclear and NBC contamination considerations.

3.3 Requirements Document:

3.3.1 Once the best technical approach has been determined, a requirements document (Required Operational Capability, Joint Services Operational Requirement, etc.) will be prepared by the CBTDEV. This requirements document states what, where, when, and how the system will be employed on the battlefield and discusses system operation and maintenance to include both during and following a nuclear and/or chemical/biological weapon tactical encounter. System performance requirements are then developed to cover the minimum essential operating characteristics that must be preserved when subjected to nuclear and/or NBC contamination environments. Typical characteristics include post-exposure retention of stored data, time after exposure at which the system is expected to be operational, allowable operator intervention to regain operational status, and allowed down time. These system performance requirements constitute the nuclear survivability requirement.

3.3.2 Although the nuclear survivability requirement is established by the CBTDEV, the CBTDEV may formally request assistance from the U.S. Army Nuclear and Chemical Agency (USANCA) in establishing a technique for achieving nuclear survivability (i.e., nuclear survivability may be achieved through hardening, redundancy, timely resupply and/or mitigation techniques).

3.3.3 As with nuclear survivability, USANCA may assist the CBTDEV in providing an appropriate NBC contamination survivability requirement (i.e., sections of equipment not required to be decontaminable [e.g., tires, undercarriage], selection of quantifiable characteristics for which decontaminability applies, selection of quantifiable characteristics for which hardness applies, selection of quantifiable characteristics for which compatibility criteria apply, and when is collective protection a viable substitute).

3.4 Nuclear Hardening Criteria:

3.4.1 Once the CBTDEV has established that hardening is to be the approach for ensuring nuclear survivability, a standard questionnaire is utilized to provide information to USANCA. Based on information given in the questionnaire, USANCA determines a set of threat levels (survivability criteria) to which the MATDEV attempts to design and develop the equipment. For this task, USANCA utilizes the documents Quadripartite Standardization Agreement (QSTAG) 244, Edition 3 entitled "Nuclear Survivability Criteria for Military Equipment" and QSTAG 620, "Consistent Set of Nuclear Survivability Criteria for Communications-Electronics (C-E)

Equipment." The methodology for developing nuclear survivability criteria found in QSTAG-244 is also promulgated within NATO by Annex A, Allied Engineering Publication-4 (AEP-4 (STANAG 4145)).

3.4.2 The evolution from nuclear survivability performance requirements to nuclear survivability criteria development is a well established procedure. The U. S. defense posture requires that the Army be ready to employ a wide variety of organizations and equipment on a wide range of missions against a wide range of threats. Each item of equipment and/or system differs in degrees of redundancy, criticality to mission accomplishment, and physical deployment. Therefore, USANCA develops mission-related, but scenario-independent, hardening criteria rather than concentrating on specific mission profiles. A basically fundamental philosophy used by USANCA is the concept of balanced survivability where the equipment is hardened according to the ability of the crew to survive. This underscores the importance of The Surgeon General's mission to increase the ability of personnel to survive.

3.4.3 The essential factors in the development of nuclear survivability criteria are presented in Figure 1. Based upon the information supplied by the CBTDEV, USANCA issues hardening criteria for all initial NWE or for HEMP only. A typical application of HEMP-only criteria would be for a system that does not require survivability to all effects because of its redundancy (or provisioning for timely resupply) on the battlefield but whose loss due to the theater-wide effects of HEMP would adversely affect the mission. If hardening against all initial NWE is required, USANCA considers the system's proposed location on the battlefield (and the corresponding threat nuclear capability), the man-machine relationship, and the crew survivability requirement in developing a set of balanced survivability criteria. The use of balanced survivability criteria ensures that the system is not left vulnerable to one or more environmental effects while having adequate survivability for all other associated effects. Once developed, the survivability criteria are presented to the CBTDEV for forwarding to the MATDEV.

3.5 NBC Contamination Survivability Criteria

3.5.1 Upon definition (required, not required, or collective protection) and refinement (degrees of decontaminability, hardness, and compatibility required) of the NBC contamination survivability requirement, NBC contamination survivability criteria must be defined. These criteria have been developed by USANCA to support current Army philosophy:

> "A soldier or crew surviving an NBC attack should be able to continue using mission-essential systems and equipment, in a full protective ensemble if necessary. When the mission permits, the systems and equipment should be capable of rapid restoration to a condition such that all operations can be continued in the lowest protective posture consistent with the mission and threat, and without long-term degradation of the materiel."

Therefore, soldiers with the ability to perform in an NBC-contaminated environment must also have mission-essential equipment with the same capability. Definition of the survivability requirement is made with risk and cost considerations according to the equipments intended method of deployment (e.g., equipment kept permanently outside under cover, and equipment deployed from protected areas).

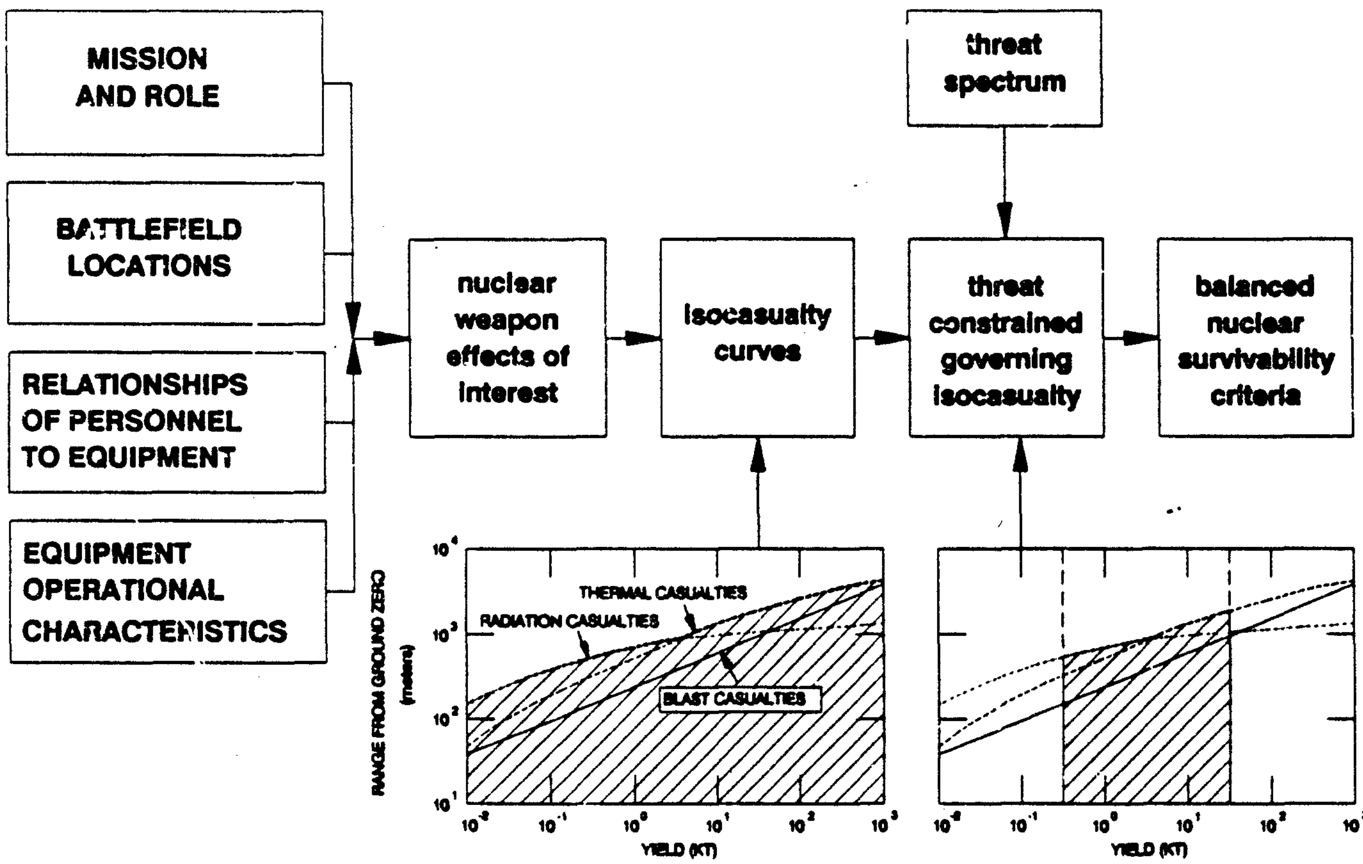

Figure 1. Isocasualty Curves and the Balanced Survivability Concept

3.5.2 The NBC contamination survivability criteria have been outlined in the "Department of the Army Approved NBC Contamination Survivability Criteria for Army Materiel." It is this letter which sets the conditions for decontaminability (amount of contamination, time allowed to decontaminate, atmospheric conditions, radiation levels), hardness (allowable degradation per time period relative to number of decontaminating procedures), and compatibility (troop performance standards) that must be accommodated by the equipment.

3.5.3 Given these criteria, the MATDEV may reference Allied Engineering Publication (AEP)-7 "Chemical Defence Factors in the Design of Military Equipment" and the Chemical Research, Development, and Engineering Center's (CRDEC) "Design Guidelines to Minimize Contamination and to Facilitate Decontamination of Military Vehicles and Other Equipment" and the "NBC Materials Handbook" for guidance on the development of NBC contamination survivable equipment.

3.6 Nuclear/NBC Contamination Environments

Tables 1 and 2 contain the typical parameters which compose the Nuclear/NBC contamination environments and the units of measurement which quantify these parameters.

TABLE 1. NUCLEAR ENVIRONMENT PARAMETERS AND UNITS

	UNITS
BLAST	
Peak overpressure (p):	psi
Overpressure duration (t):	sec
Overpressure impulse (I):	psi-sec
Peak dynamic pressure (q):	psi
Dynamic pressure positive duration (t):	sec
Dynamic pressure impulse (I):	psi-sec
Peak underpressure (p):	psi
Arrival time (t):	sec
THERMAL	
Total thermal energy (Q):	cal/cm^2
Maximum irradiance (Q_{max}):	cal/cm^2-sec
Time to maximum irradiance (t):	sec
(A description of the thermal pulse)	
INITIAL NUCLEAR RADIATION	
Tissue Absorption:	
Total dose (D_t):	rad(tissue)
Maximum gamma contribution (D):	rad(tissue)
Maximum neutron contribution (D_n):	rad(tissue)
Silicon absorption/displacement damage:	
Maximum combined neutron/gamma	
Ionizing dose (D_i):	rad(Si)
(Pulse description)	
Maximum neutron fluence (1 MeV equivalent damage in Silicon) (F_n):	n/cm^2
Peak Gamma Dose Rate (Pulse description):	rad(Si)/sec
ELECTROMAGNETIC PULSE (EMP)	
(See Annex A of QSTAG-244)	

TABLE 2. NBC CONTAMINATION ENVIRONMENT PARAMETERS AND UNITS

CRITERIA	UNITS
Typical Contamination Scenario	
Contaminant Density	
Chemical Agents	g/m^2
Biological Agents	$spores/m^2$
Residual Nuclear Radiation	g/m^2
Size of Individual Contaminant Particles	
Chemical Agents	mm (diameter)
Biological Agents	micrometers
Residual Nuclear Radiation Particulate	micrometers
Residual Nuclear Radiation Activity	$gigaBq/m^2$
Residual Nuclear Radiation Dose	rads

SECTION 4. INCORPORATING SURVIVABILITY AND HARDENING INTO THE ACQUISITION PROCESS

4.1 Equipment Acquisition Phases

Both nuclear and NBC contamination survivabilities are addressed early in the CE Phase (1-2 years) of the system acquisition process. This is done through the development of the O&O Plan and other requirements documents, the survivability criteria, and the hardening criteria. With these documents, the MATDEV is prepared to initiate the process for awarding a contract to investigate the best technical approach. Follow-on phases are the Demonstration and Validation (3-4 years), the Full-Scale Development (4-5 years), and finally the Production and Deployment. In each of these phases Request for Proposal (RFP) offers, Source Selection Proceedings, and contract monitoring efforts are conducted by the MATDEV. The above mentioned acquisition phases are termed the traditional acquisition process. An alternative process is the so-called streamlined acquisition process which consists of phases labeled Proof of Principle (1-2 years), Development Proveout (4 years), and Initial Production and Deployment (2 years). Another variation occurs when the Army is interested in Nondevelopmental Items, attempting to take full advantage of the state-of-the-art technology available in the industry. As a result of the Full Scale Development Phase, a Product Improvement Program (PIP) may be initiated which could involve design changes incorporated to enhance system survivability. Both the system acquisition process and the streamlined acquisition process, as adapted for medical materiel, are shown in Figures 2 and 3. The medical materiel acquisition process is generally the same as that used for AMC development programs with one exception. AMC programs are often larger scale developments and require a different decision review body than the In-Process Review (IPR) used by the medical community. The Army Materiel Command has made available procedures and agencies which provide assistance to the MATDEV in the areas of initial NWE and NBC contamination. The Harry Diamond Laboratories (HDL), Nuclear Effects Support Team (NEST), and CRDEC provide technical expertise in the initial NWE and NBC contamination areas, respectively.

4.2 Nuclear Hardening and the NEST

4.2.1 The primary Army government group available to the MATDEV for assistance in the implementation of nuclear hardening in the design of equipment, is NEST. NEST is available for consultation at any time, but specifically provides support in the area of initial NWE for the development of RFPs, the conduct of Source Selection Evaluation Board (SSEB) activities, and the continuous monitoring of contract implementation for the MATDEV.

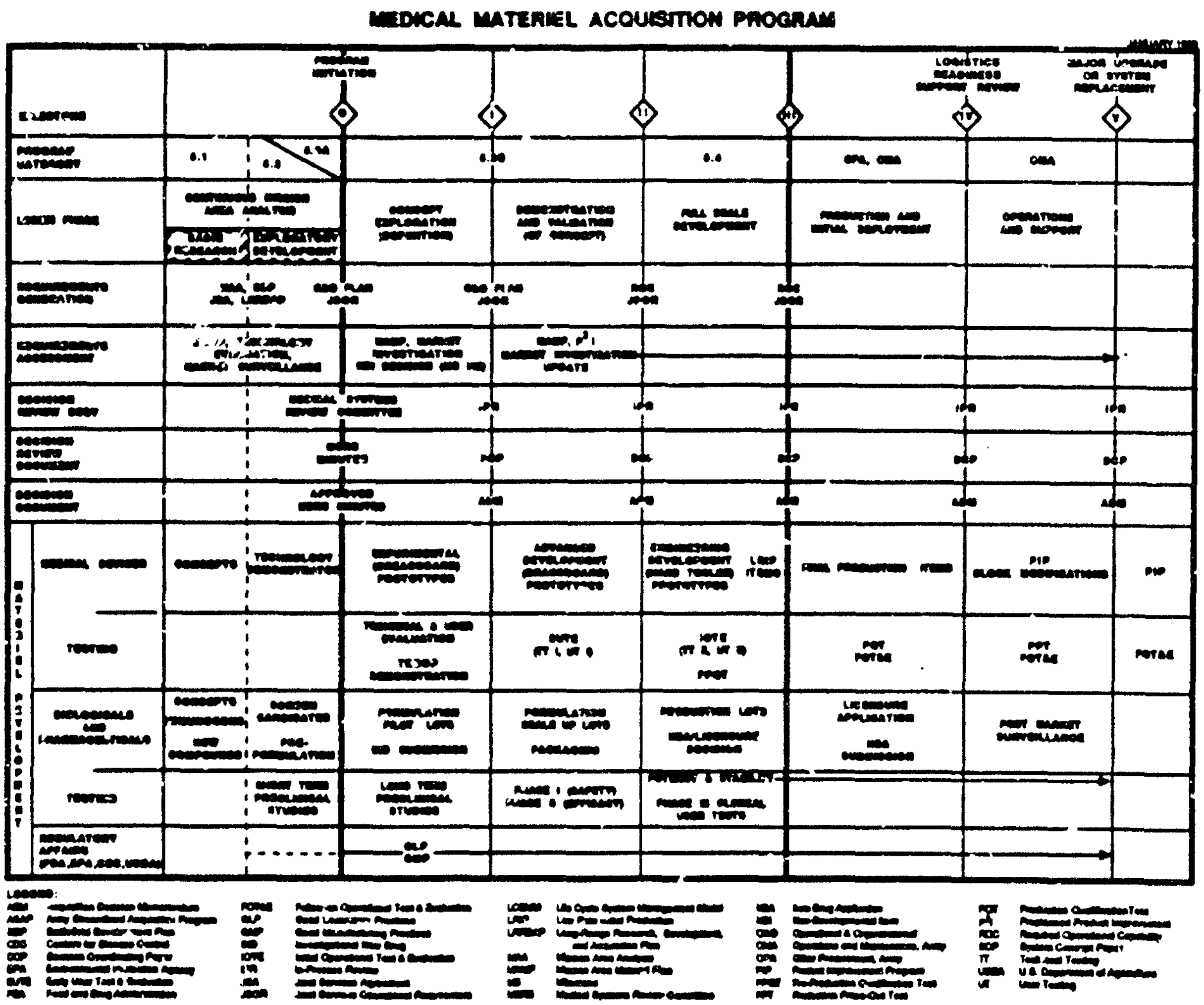

Figure 2. The System Acquisition Process for Medical Materiel

STREAMLINED MEDICAL MATERIEL ACQUISITION PROGRAM

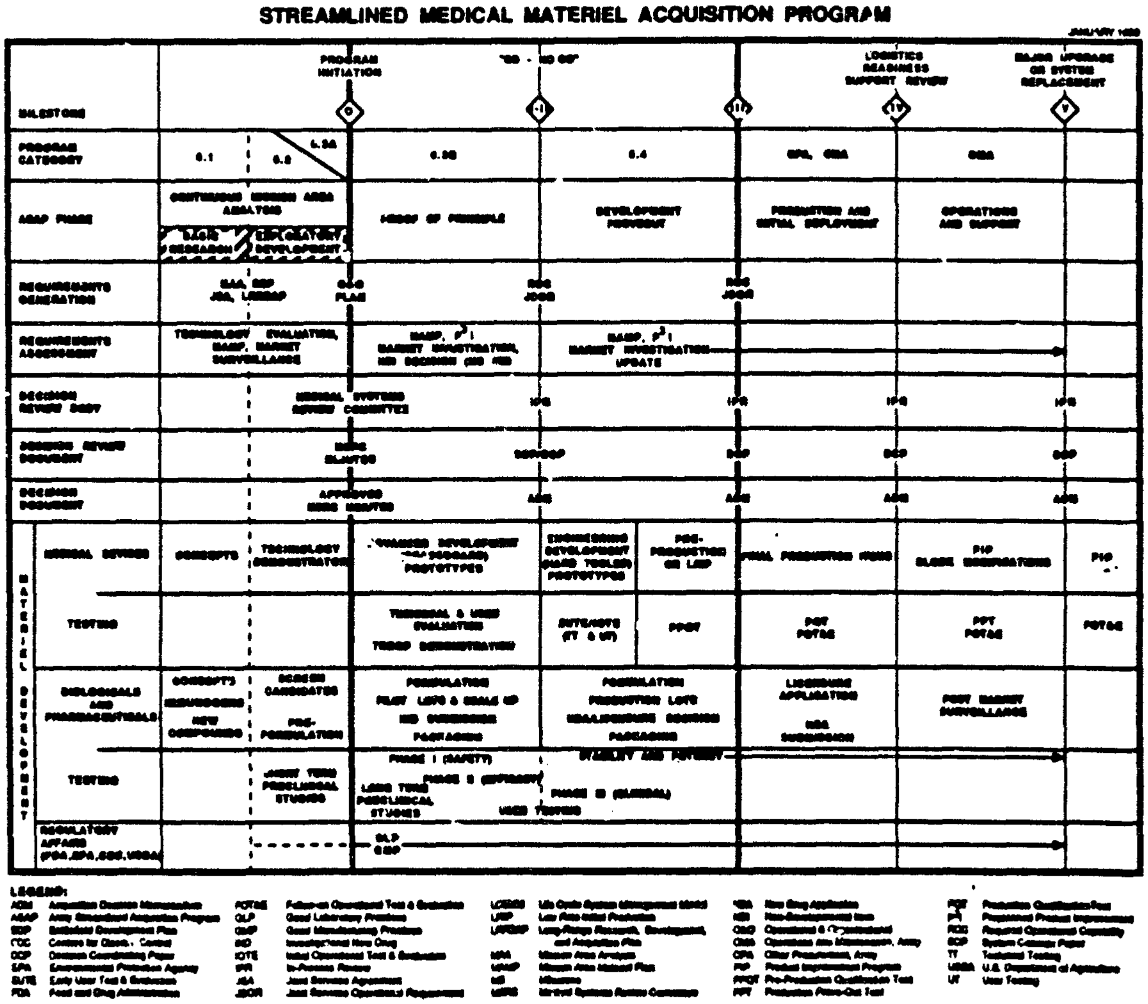

Figure 3. The Streamlined System Acquisition Process for Medical Materiel

4.2.2 Nuclear Survivability Data Item Descriptions (DIDs) - NEST provides the following paragraphs, included in the Statement of Work (SOW), describing six DIDs. The DIDs are designed to help ensure that the system will eventually meet the USANCA hardening criteria. The contractor shall prepare and deliver the data and information in accordance with preparation instructions, specific tasks, requirements, and schedules delineated in the Contract Data Requirements List (CDRL) for the following DIDs:

(1) DI-NUOR-80156, NUCLEAR SURVIVABILITY PROGRAM PLAN - This DID describes how the contractor has structured the nuclear survivability program (design, analyses, tests, and management). The plan is for the purpose of assuring that the contractor's Nuclear Survivability Program will meet the contractual requirements in a cost-effective manner.

(2) DI-R-1759A, NUCLEAR WEAPONS EFFECTS TEST PLAN - This DID specifies that the contractor describe the general procedures and guidelines for planning and conducting the nuclear survivability tests and identifies specific tasks which must be planned.

(3) DI-R-1760A, NUCLEAR WEAPONS EFFECTS TEST REPORT - This DID specifies that the contractor must document the results of the nuclear survivability tests.

(4) DI-R-1761A, NUCLEAR SURVIVABILITY DESIGN PARAMETERS REPORT - This DID specifies that the contractor identify the system features that control the system's nuclear survivability in development and production and assist in retaining survivability during system maintenance and overhaul.

(5) DI-R-1762A, NUCLEAR SURVIVABILITY ASSURANCE PLAN - This DID specifies that the contractor describe the methods and procedures for preserving the nuclear survivability during the production acquisition phase. This DID is required at the end of the development phase in order to ensure that the proper engineering and planning has been done to support production activities.

(6) DI-R-1763A, NUCLEAR HARDNESS MAINTENANCE AND SURVEILLANCE PLAN -This DID specifies that the contractor describe the precautions and procedures to be used during regular maintenance and repair to assure that the system's nuclear survivability is maintained and verified in system deployment. This DID is submitted at the end of the development phase to ensure that hardness maintenance/surveillance procedures have been addressed such that the production activities can proceed unimpeded.

4.2.3 Nuclear Survivability Statement - With regard to the RFP, NEST provides a Nuclear Survivability Statement.

4.2.3.1 For Part I of General Instructions which appear in Section L of the Solicitation Instructions, the following is provided:

4.2.3.1.1 The nuclear survivability portion of the proposal for this acquisition shall present a detailed description of the activities which the contractor shall perform to ensure the survivability of the mission essential equipment delivered under this procurement. The proposal shall include specific discussions of all analysis, engineering design, and environmental testing which comprise the survivability program. In preparing this portion of the proposal, the contractor shall use DID DI-NUOR-80156 (NUCLEAR SURVIVABILITY PROGRAM PLAN) as a guide.

4.2.3.1.2 The proposal shall identify the nuclear survivability considerations and tradeoffs which were priority factors in the selection of the technologies, components, assemblies, and equipment being procured under this action. The contractor shall describe the time-phased plan of major nuclear hardening tasks for analyses, implementation of upgrades, hardness verification, and ensuring that the nuclear hardness is retained through hardness assurance and hardness maintenance/surveillance. The proposal shall identify the areas of risk in meeting the specified nuclear survivability requirements.

4.2.3.1.3 The proposal shall describe (1) the offeror's experience in the hardening, verification, and production of nuclear survivable equipment; (2) the nuclear survivability program management structure; (3) nuclear weapons effects expertise assigned to the program; and (4) the nuclear survivability program interfaces with other program disciplines in ensuring a coordinated approach.

4.2.3.1.4 In-house and subcontracted personnel must be identified by name, specific tactical nuclear hardening experience, and assigned responsibilities on this program. Engineering hours and associated labor caliber (including that for the data item deliverables) must be identified.

4.2.3.2 For Part II, specific instructions which are provided for inclusion in Section L of the Solicitation Instructions are as follows:

4.2.3.2.1 The contractor's response to the nuclear survivability requirement should be contained comprehensively in a separate classified volume (e.g. Annex, Appendix, Addendum, etc.). This allows the freedom of mentioning nuclear criteria in the discussion of the nuclear hardening approach. This approach does not preclude the contractor from also including nuclear survivability considerations in the body of the proposal where this is necessary to substantiate the approach. In the event of conflicts between statements contained in the body of the proposal and those in the classified volume, the statements in the classified volume will be considered contractually binding.

4.2.3.2.2 The contractor shall provide a breakdown of the engineering manhours proposed for the preparation of each of the nuclear DIDs. This applies to both the prime contractor and any subcontracted nuclear expertise to be assigned to the program. Personnel resumes shall contain the person's (1) name, (2) technical background, (3) intended job assignment for the program, and (4) specific accomplishments in tactical nuclear hardening.

4.2.3.2.3 The contractor shall delineate existent company experience and accomplishments in prior nuclear survivability analyses and hardening efforts.

4.2.3.2.4 The contractor shall clearly identify the management structure proposed for the nuclear survivability program.

4.2.4 Performance Specifications - With regard to the RFP, the following requirement statement is provided for Section 3 entitled "System Nuclear Survivability".

4.2.4.1 All mission-essential mechanical configurations, optical components, electronic assemblages, electronic equipments, electronic circuits, and electronic pieceparts shall conform to the requirements of their respective performance specification after exposure to the nuclear environments specified in Appendix ___.

4.2.4.2 The equipment/system shall autonomously recover from the effects induced by exposure to the nuclear environment. Recovery time, or permissible outage time, shall be consistent with the requirements of the performance specifications. Hardware and software design implementations shall incorporate specific measures to ensure that, after exposure to the nuclear environment, the equipment/system is not affected by erroneous data generated during exposure to the nuclear environments.

4.2.5 Quality Assurance Provisions - With regard to the RFP, the following with respect to Section 4 concerning quality assurance provisions is provided:

4.2.5.1 (4.x.1) General - To assure that the equipment/system is survivable to the nuclear environments of Appendix ___, a Hardness Assurance Program shall be conducted. The Hardness Assurance Program shall be described in accordance with the requirements of DID DI-R-1762A (NUCLEAR SURVIVABILITY HARDNESS ASSURANCE PLAN). This plan shall describe all activities anticipated during the production of the equipment/system, including design changes, analytic efforts, and testing (component, assembly and equipment/system).

4.2.5.2 (4.x.1.1) Design Parameters Report - To ensure that changes or modifications to the equipment/system made during the course of the contract do not decrease the nuclear survivability of the equipment/system, all changes and/or modifications shall be analyzed and/or tested to demonstrate their survivability to the nuclear environments. The latest version of the appropriate DESIGN PARAMETERS REPORT (DI-R-1761A) shall be updated to contain the results of these analyses and tests.

4.2.5.3 (4.x.1.2) Facilities - Facilities which are used to simulate the specific NWE environments shall be capable of reproducing the environments or in the event an environmental simulator cannot fully replicate the environment, an analysis shall be performed to demonstrate the suitability of the simulation test and its relationship to the specified threat environment. The contractor shall ensure that each simulation facility used has maintained calibration certification.

4.2.5.4 (4.x.1.3) Test Plans and Reports - All survivability validation or qualification tests shall be documented through the use of test plans and test reports. Test plans shall conform to DI-R-1759A (NUCLEAR WEAPONS EFFECTS TEST PLAN). Tests reports shall conform to DI-R-1760A (NUCLEAR WEAPONS EFFECTS TEST REPORT). Delivery of plans and reports shall be in accordance with the CDRL. Test plans shall be approved by the Government prior to the conduct of any test.

4.2.5.5 (4.x.2) Electromagnetic Pulse (EMP) - The equipment in its intended deployment configurations and operational modes, which are worst case for coupling of nuclear EMP environments, shall be exposed at the threat levels (hardening criteria) specified in Appendix ___.

Analyses shall be performed to determine which of the EMP environments and which of the intended deployment configurations and operational modes are worst case for EMP coupling to the equipment/system. Hardening criteria threat level tests shall be performed at an appropriate simulator capable of illuminating the entire deployed equipment. Placement of the equipment within simulator test volume must ensure worst case coupling of the environment to the equipment and cabling. The equipment shall meet the requirements of the performance specifications of Section 3 upon completion of the threat level tests.

4.2.5.6 (4.x.2.1) Protected Equipment Inputs - Current injection tests are required to verify the functionality of, and hardness margin afforded by, the protection devices employed at the equipment signal and power interfaces.

4.2.5.7 (4.x.3) Neutron Fluence - The equipment shall be exposed in such a manner that all optical components, electronic pieceparts, and circuits receive the neutron fluence specified in Appendix ___. The equipment shall be exposed while in its worst case electrical bias configuration. The equipment shall meet the requirements of the performance specifications specified in Section 3 following exposure to the neutron fluence.

4.2.5.8 (4.x.4) Total Dose - The equipment shall be exposed in such a manner that all optical components, electronic pieceparts, and circuits receive the total dose specified in Appendix ___. The equipment shall be irradiated while in its worst case electrical bias configuration. The equipment shall meet the requirements of the performance specifications of Section 3 following the total dose exposure obtained by Cobalt 60 irradiation in which the total dose is delivered at the rate of 100-200 Rads(Si) per second.

4.2.5.9 (4.x.5) Peak Gamma Dose Rate - The equipment shall be exposed in such a manner that all optical components, electronic pieceparts, and circuits receive the peak gamma dose rate specified in Appendix ___. The equipment shall be exposed while in its worst case electrical bias configuration. The equipment shall meet the requirements of the performance specifications of Section 3 following exposure to the peak gamma dose rate.

4.2.5.10 (4.x.6) Thermal Radiation and Air-Blast - The equipment in its worst case intended deployment configuration for nuclear thermal radiation and air-blast shall be exposed to the levels specified in Appendix ___. Analyses (and test where appropriate) shall be performed to account for the synergistic effects of the thermal radiation received before the air-blast. The test environments of the thermal radiation followed by the air-blast shall be applied in the proper time-phased sequence as occurs for the tactical nuclear threat that applies. The equipment shall meet the requirements of the performance specifications of Section 3 following exposure to these environments. Where such thermal radiation/air-blast time-phased testing is inappropriate, the thermal radiation and air-blast tests shall be performed separately as specified below in Paragraphs 4.2.5.11 (4.x.6.1) and 4.2.5.12 (4.x.6.2).

4.2.5.11 (4.x.6.1) Thermal Radiation - The equipment in its intended deployment configuration, which are worst case for the thermal radiation environment, shall be exposed to the thermal radiation environment as specified in Appendix ___. The thermal radiation levels shall be uniformly delivered over the entire exposed surface(s) of the equipment. The equipment shall meet the requirements of the performance specifications of Section 3 following exposure to thermal radiation.

4.2.5.12 (4.x.6.2) Air-Blast - The equipment in its intended deployment configuration, which are worst case for nuclear air-blast environment, shall be subjected to air-blast tests at the appropriate air-blast facilities that provide the specified air-blast levels, as specified in Appendix ___. For equipment housed within an enclosure, the equipment shall be subjected to the induced shocks and accelerations that are transmitted through the enclosure when the enclosure is subjected to the specified air blast environment. In either case, the equipment shall meet the requirements of the performance specifications of Section 3 following exposure to air-blast.

4.2.6 Statement of Work (SOW) Input for Nuclear Hardening - With regard to the RFP, the following SOW information is provided:

4.2.6.1 General

The contractor shall conduct a comprehensive nuclear survivability program to ensure that the equipment/system developed under this contract shall survive specified nuclear environments. The program elements specified herein constitute the minimum acceptable components of the survivability program.

4.2.6.2 Hardening Approaches

4.2.6.2.1 Electromagnetic Pulse (EMP) and System-Generated EMP (SGEMP):

All mission-essential equipment including that designed and fabricated by the contractor, those purchased commercially off-the-shelf, military inventory items, and mission-essential Government-Furnished Equipment (GFE) shall be analyzed under worst-case deployment configuration for EMP/SGEMP survivability. To ensure the nuclear survivability of this equipment, the contractor shall incorporate the appropriate protection devices into the equipment design and shall demonstrate through the use of appropriate system-level EMP/SGEMP development tests that the equipment satisfies the specific nuclear hardening criteria. In the event the simulator cannot duplicate all of the essential features of the specified nuclear environment, a combination of appropriate analyses and tests shall be performed to validate the survivability of the equipment.

4.2.6.2.2 Initial Nuclear Radiation (INR), Thermal Radiation and Air-Blast

4.2.6.2.2.1 All mission-essential equipment designed and fabricated specifically for the system by the contractor shall be analyzed for survivability to INR (neutrons and gammas), thermal radiation, and air-blast environments. If protection devices and hardened designs are deemed necessary to ensure the nuclear survivability of these equipments, the contractor shall incorporate the protection devices and designs and shall demonstrate through appropriate validation techniques that the equipment satisfies the specified nuclear hardening criteria.

4.2.6.2.2.2 The nuclear hardening approaches shall account for the equipment being passive (i.e., de-energized) as well as being powered (i.e., energized), and shall account for the Contractor-Furnished Equipment (CFE) and the Government-Furnished Equipment (GFE) configured for the worst-case system response during exposure. The contractor shall ensure that the GFE is not degraded by nuclear environment-induced signals coupled from the CFE; and, vice versa, that the CFE is not degraded by nuclear environment-induced signals coupled from the GFE. The contractor shall perform appropriate analyses to account for the synergistic effects of thermal radiation received before the air-blast. Acceptability of the optical components and electronic piece parts, circuits, equipment, assemblages, etc. shall be determined by the procuring agency from the INR response data and mathematical analyses supplied by the contractor. Nuclear survivability at the specified system temperature extremes shall be demonstrated by appropriate analyses.

4.2.6.2.2.3 The contractor shall assess all other mission-essential equipment including commercial off-the-shelf equipment, military inventory equipment, and GFE for survivability to the specified initial nuclear radiation, thermal radiation, and air-blast environments. These assessments shall be documented fully and explicitly in the contractor's submittal of DI-R-1761A (NUCLEAR SURVIVABILITY DESIGN PARAMETERS REPORT) and shall identify the hardness margins and define the necessary protection devices and hardened designs necessary to correct existing deficiencies. For each deficiency the contractor shall identify the cost, performance, and schedule impacts of correcting the deficiency. The Government will approve the adequacy of assessments already performed for the system equipment, and will direct the contractor accordingly on whether further assessments are necessary. Nuclear simulation testing of the system equipment may be required, in conjunction with the assessments, to demonstrate compliance.

4.2.6.3 Hardness Margin Guidance

4.2.6.3.1 Sufficient hardness margins are required to ensure that the system survives the specified NWE environments and to avoid costly hardness assurance and hardness maintenance/surveillance programs and procedures in the production and deployment phases. The hardness margins account for parts variabilities and the effects of aging and temperature. The table of hardness margins on the following page are provided as guidelines and the contractor is required to properly justify (to the Government's satisfaction) the use of piece parts, circuits, and designs whose hardness margins are less than those stated here.

TABLE 3. HARDNESS MARGIN GUIDANCE

ENVIRONMENT	HARDNESS MARGIN CATEGORIES I	II
Electromagnetic Pulse (EMP)		
Voltage/Current ratio	2 to 10	>10
Corresponding Voltage and Current Hardness Margins above the Damage Thresholds	6 to 20 dB	>20 dB
Initial Nuclear Radiation (INR)		
Neutron Fluence	2 to 10	>10
Total Dose	2 to 10	>10
Gamma Dose Rate		
Upset	2 to 5	>5
Burnout	2 to 10	>10
Latchup	2 to 5	>5
Thermal Fluence	1.3 to 1.5	>1.5
Air-Blast Peak Overpressure	1.3 to 1.5	>1.5

4.2.6.3.2 Items whose hardness margin fall below the lower bound of Category I are unacceptable. The contractor should avoid using items having hardness margins in the Category I range because of the hardness assurance/hardness maintenance impacts later in the life cycle (i.e., piece parts screens, lot sample testing, etc.). The contractor shall incorporate parts with the highest margin practical to avoid these adverse impacts. Category II parts may not need special controls.

NOTE: Hardness critical items (HCIs) which require special designs, fabrications, or processes to achieve the required nuclear hardness levels must be identified to distinguish these "special" parts from parts which are not fabricated with the particular processing to achieve the required hardness. The drawings/specifications which provide the details of these special items shall be annotated in accordance with DOD-STD-100.

4.2.6.3.3 The hardness margins of hardness critical items and the categorizations of hardness critical items shall be identified in the NUCLEAR SURVIVABILITY ASSURANCE PLAN (DI-R-1762A).

Information Note:

Use of appropriate radiation hardness assurance designated parts is acceptable in lieu of using the comparable Harry Diamond Laboratories (HDL) furnished design margins. The nuclear survivability design margins are supplied ONLY to provide a significant degree of certainty that the USANCA nuclear hardening criteria are achieved; the design margins are not in themselves a requirement. An alternative to using design margins is to select parts with tested and guaranteed radiation response limits which meet the criteria. Parts specified through the military specifications MIL-S-19500 and MIL-M-38150 using radiation hardness assurance (RHA) level designators may be used to handle neutron fluence and total dose environments. Some RHA products are currently on the Qualified Products List (QPL) while others are in the process of being submitted to the Defense Electronics Supply Center, Dayton, Ohio. Since the General Specifications have the RHA requirements documented, any product can be added to the QPL through a vendor or by an original equipment manufacturer (OEM) request to a vendor. Additionally RHA products can be specified in a standard military drawing. Vendor certification of RHA-level designated parts is done by a combination of design margins and testing on an ongoing basis. It is not the U.S. Army's intention to put design margins on top of design margins. Rather, RHA-level designated parts which have been properly certified to meet or exceed the USANCA nuclear hardening criteria values will satisfy the piecepart certification requirement in the areas in which they are certified. Note that RHA-level designation does NOT address dose rate specifications, and these will have to be handled separately. Dose rate induced effects are best addressed through circuit design techniques and/or technology selection.

4.2.6.4 Contractor Formulation of Responses to Nuclear Survivability Data Items

4.2.6.4.1 The contractor shall make maximum utilization of the Nuclear Survivability Design Advisor (NSDA). The NSDA is a compilation of nuclear weapons effects expert system software available from the NEST (Phone: (202) 394-2857). The NSDA is provided in order to assist in formulating responses to the nuclear survivability data item deliverables on this contract. The contractor shall interface with the software to generate the required plans/reports which are to be used as deliverables. These NSDA interactions require that the contractor have the necessary administrative and technical information in hand and ready for inclusion. Scheduling the use of the software requires that the contractor contact the NEST to ensure reserving adequate initialization time consistent with the data item delivery requirements specified in the contract.

4.2.6.4.2 The contractor shall review the plans/reports generated directly by the expert system interaction, and shall ensure that all aspects of information required for the data items are coherent and complete. Revisions incorporated into the report generated by the NSDA shall be justified as a separate letter attachment to the report. The contractor shall not construe this requirement as a guarantee that the submittal will be acceptable.

4.2.6.5 Nuclear Weapons Effects Data

4.2.6.5.1 The contractor shall deliver to the Government all nuclear test data acquired in this program. The data shall be sanitized such that there is no traceability of the data to this program. The data shall be provided to the DASIAC data base sponsored by the Defense Nuclear Agency at the following address: Kaman-Tempo; P. O. Drawer QQ; Santa Barbara, California, 93102. The piece parts, INR data in particular, must be provided to the Electronics Radiation Responses Information Center (ERRIC) (a subprogram of the DASIAC). The format of the piece parts data for the ERRIC is described in DI-R-1760A.

4.2.6.5.2 The contractor shall ensure that appropriate nuclear survivability information is incorporated into the Integrated Logistic Support (ILS) documentation which consist of the Logistic Support Analysis (LSA) and the Logistic Support Analysis Record (LSAR)

4.2.6.5.3 Hardness Assurance and Hardness Maintenance/ Surveillance - The contractor shall evaluate each of the hardening approaches, hardening techniques, and hardened designs with the objective of achieving a hardened system which is easy to maintain and cost-effectively inspected and tested to ensure that hardness is retained. The contractor's evaluation shall include, but not be limited to, such considerations as cost, productivity, reliability, weight, mobility, Manpower and Personnel Integration, testability, the need for (and projected availability of) special materials and hardware, justification for source controls of parts, and defining simple methods for hardness verification (hardness surveillance) in the field. The contractor shall implement hardening approaches, techniques, and designs that are cost-effective for the life cycle.

4.2.7 Other NEST RFP Inputs

The NEST provides other specific items for inclusion in the RFP. These include the DIDs themselves, forms, Army Guidance formats for documenting the various (six) DIDs, the Document Summary List for Solicitation, an Applicable Documents List, and Data Selection Sheets.

4.3 NBC Contamination Survivability Criteria and CRDEC

4.3.1 AMC has assigned CRDEC as the lead activity with the responsibility of establishing a technical support program for MATDEVs. As with NEST, CRDEC supports the preparation of RFPs and SOWs, and can participate or provide support for SSEBs and key Design Reviews.

4.3.2 NBC Contamination Survivability DIDs - CRDEC has prepared seven DIDs for incorporation into the RFP. These DIDs govern the preparation of the plans/reports required for documentation of the NBC contamination survivability effort. The contractor will be required to prepare and deliver the data and information in accordance with preparation instructions, specific tasks, requirements, and schedules delineated in the CDRL for the following DIDs:

(1) DI-R-1778, NBC CONTAMINATION SURVIVABILITY PROGRAM PLAN - This document outlines the conduct of the contractor's NBC Contamination Survivability Program. The necessary design considerations analyses, tests, and management activities to ensure NBC contamination survivability will be discussed.

(2) DI-R-1779, NBC CONTAMINATION SURVIVABILITY TEST PLAN - This document describes the general procedures, terms, and conditions governing the planning, preparation, implementation, and reporting of the NBC contamination survivability test program.

(3) DI-R-1780, NBC CONTAMINATION SURVIVABILITY TEST REPORT - This document contains the results of tests performed on parts, components, materials, processes, equipment, subsystems and/or systems.

(4) DI-R-1781, NBC CONTAMINATION SURVIVABILITY DESIGN PARAMETERS REPORT - This document specifies the features that constitute and control a system/subsystem/equipment NBC contamination survivability. This is necessary to assist in retaining NBC contamination survivability during later modifications such as ECPs and PIPs as well as throughout overhaul and system maintenance operations.

(5) DI-R-1782, NBC CONTAMINATION SURVIVABILITY ASSURANCE PLAN - This document outlines the contractor's plan for preserving NBC contamination survivability during the production acquisition phase.

(6) DI-R-1873, NBC CONTAMINATION SURVIVABILITY MAINTENANCE PLAN - This document describes the special maintenance and repair procedures necessary to ensure that NBC contamination survivability is maintained during the deployment phase. The test procedures for verifying this capability are also discussed.

(7) DI-R-1784, NBC CONTAMINATION SURVIVABILITY FINAL REPORT - This document discusses all phases of work performed in the NBC Contamination Survivability Program.

4.3.3 NBC Contamination Survivability Statement - With regard to the RFP, CRDEC assists the MATDEV in developing an NBC Contamination Survivability Statement. The following serves as a guideline, from which, the statement is developed and tailored to the specific system.

4.3.3.1 For the General Instructions which appear in Section C of the Solicitation Instructions, the following information is provided:

4.3.3.1.1 The NBC contamination survivability portion of the proposal for this acquisition shall include a detailed description of the approach for materials selection, circuit design, mechanical design, and system integration to develop an end-item which is survivable in the NBC contaminated environment.

4.3.3.1.2 The proposal shall include a listing of the detailed design guidelines to insure NBC contamination survivability, a detailed description of the approach proposed for verification of NBC contamination survivability. The proposal will address NBC contamination survivability in entirety including concern with protecting personnel and equipment from the effects of nuclear fallout, neutron-induced gamma radiation, chemical and biological agents, and decontamination materials and procedures so that mission-essential operations can be performed. Concern for the effectiveness and efficiency of personnel who must perform tasks while protected from the NBC hazard is also included.

4.3.3.1.3 The proposal shall include the resumes of personnel, verifying their expertise in NBC threat and contamination survivability. Overall company experience in developing NBC contamination-survivable systems must be identified to demonstrate company competence in addressing the question of NBC contamination survivability. The number of labor hours, with the associated caliber of labor which will be applied to accomplish and verify NBC contamination survivability, must be stated. If subcontractors are utilized to provide this capability, their costs, labor hours, and expertise in NBC contamination survivability must be broken out.

4.3.3.1.4 All of the information requested in this NBC contamination survivability statement must be contained in a separate section of the proposal.

4.3.3.2 For Part II of the RFP, the following requirement is provided:

4.3.3.2.1 All contractor-furnished mechanical configurations, optical components, electronic assemblies, electronic equipment, electronic circuits, and pieceparts shall withstand exposure to the NBC contamination environment likely to be encountered. If modification is deemed necessary to ensure the survivability of the equipment, the contractor shall implement the modifications and shall demonstrate, through the use of appropriate validation techniques, that the equipment shall be survivable.

4.3.4 Specific Design Requirement Input

4.3.4.1 The following requirement is provided for inclusion in Section C of the Solicitation Instructions.

4.3.4.2 The (specified equipment) shall be capable of meeting the requirements of AR 70-71 for NBC Contamination Survivability of Army Materiel, and Department of Army Approved Quantitative NBC Contamination Survivability Criteria, for Army Materiel.

4.4 The Nuclear and Chemical Survivability Committee and Requests for Waivers

The U.S. Army Nuclear and Chemical Survivability Committee (NCSC) is responsible for implementing policies and procedures necessary to achieve the goals of AR 70-60 and AR 70-71 as well as acting as monitor of the Nuclear and NBC Contamination Survivability Programs. Proposed modifications or Requests For Waivers to nuclear and NBC contamination survivability criteria and/or the associated testing must be reviewed by the NCSC, who approves or denies these proposals. This may also include any Engineering Change Proposals (ECPs) which have potential impact on hardening effectiveness. A HQDA directed protocol (developed by the

Ballistics Research Laboratory for USANCA), on format for submitting requests for waiver of nuclear hardening criteria and NBC contamination survivability criteria is available for use by MATDEV/ CBTDEV. The protocol provides methodology for conducting nuclear and NBC contamination survivability operational effectiveness and cost trade-off analysis. Request for copies of the protocol should be forwarded to: Director, US Army Ballistics Research Laboratory, ATTN: SLCBR-DD-T (Tech Rpt BRL-TR-3019), APG, MD 21005-5066.

SECTION 5. TEST AND EVALUATION

5.1 Introduction

5.1.1 Verification that the hardening criteria are satisfied and validated prior to Army's acceptance is primarily achieved by testing. In some cases, analysis in combination with testing, is acceptable. To ensure that testing procedures are valid, the MATDEV is required to consult with NEST for NWE advice and the CRDEC for advice concerning NBC contamination. Both of these groups provide the MATDEV with experts in the various areas of interest.

5.1.2 In the case of NBC contamination, U.S. Army Test and Evaluation Command (TECOM) Test Operations Procedure (TOP) 8-2-510, NBC Contamination Survivability, July 1982, outlines NBC contamination survivability testing procedures for large items decontaminated exteriorly while TOP 8-2-11 is the analog for small items. Consultation with CRDEC ensures that interpretation of these TOPs is accurate and that appropriate testing is performed. Although the TOPs are comprehensive, incorrect interpretation could lead to substandard development of survivable equipment. Consultation with USANCA and CRDEC minimizes this possibility.

5.2 Overview of Validation Testing

5.2.1 Throughout the acquisition process, it is necessary to perform tests to validate the design and performance of military materiel. For those systems which have been designated mission-essential, this testing must include procedures to verify system survivability. Validation testing used during the acquisition process is divided among two types: user testing (UT) and technical testing (TT). User testing generally refers to the testing conducted to evaluate the effectiveness of training, logistics, doctrine, operating instructions, and actual technical performance in an operational environment, and any other issues relating to the soldier/equipment relationship in a combat setting. Tests which provide data on the achievability of technical characteristics, ruggedization of hardware, safety, technical performance of production units, and other issues pertaining to equipment-specific technical parameters are termed TT.

5.2.2 These validation tests are performed at each stage of acquisition with testing structured to support the particular stage of development. Preliminary TT and UT (Technical Feasibility Tests and Concept Evaluation Program Tests); are used to provide an initial database containing information such as: feasibility of system specifications, compatibility/interoperability with other systems, technical risks, and potential doctrinal and training issues. This information aids in the development of the Acquisition Strategy (AS) which provides the conceptual framework for materiel acquisition. Once an AS has been developed, a test program is structured to support the concept.

5.2.3 TT I (Development Test I) and UT I (Early User Test and Evaluation) begin to examine actual performance and compliance with specifications. TT I involves examining the system's ability to perform to the technical levels specified in requirements documents. TT I reveals areas that: require refinement and/or ruggedization; are incompatible with other equipment; and present considerable safety and technical risks. UT I begins to examine actual field performance under realistic combat conditions. The issues of logistics, training, operating instructions, and the soldier/equipment interface are examined.

5.2.4 TT II (Development Test II) and UT II (Initial Operational Test and Evaluation) continue to validate the design and performance of advanced development prototypes. Depending on the degree of development, a Preproduction Qualification Test may be performed. At this stage, units should be fabricated to the proposed production specifications and drawings and also be prepared to undergo reliability and maintainability demonstration tests. By the end of this development/testing phase, the operational and technical parameters of the design configuration should be validated.

5.2.5 After final prototypes have been established and the system enters into production, Production Qualification Testing (PQT) and possibly Follow-On Test & Evaluation (FOT&E) are run. PQT is used to examine the results of the manufacturing process to ensure that no performance compromises have been introduced in the production process. FOT&E may be needed to assess system training and logistics; to verify correction of deficiencies, and to ensure that production items meet operational effectiveness thresholds.

5.2.6 Testing for NBC contamination and nuclear survivability must be a component of all states of TT and UT; however, the aim of each stage of testing is different. For example, testing in the Demonstration and Validation phase would emphasize (1) ensuring that the hardening approach is feasible and (2) uncovering any equipment vulnerabilities. Testing in the Full-Scale Development phase would involve validating the hardened design and uncovering any new weaknesses resulting from design changes. Concerning production models, hardness validation testing may or may not be required depending on evaluations made by the Configuration Control Board. This committee evaluates changes made to the established design and how they may impact on system performance, to include how survivability may be affected.

5.2.7 Nuclear survivability is an issue to be resolved through TT and requires the use of special simulation facilities. NBC contamination survivability testing is handled through both TT and UT. The issues of decontaminability and hardness are inherently TT issues while compatibility, due to the human factors aspect, is most effectively evaluated by UT.

5.2.8 Nuclear survivability validation cannot be assured to 100% accuracy. There is also no single method that provides a suitable degree of certainty. Most initial NWE simulators have some limitation that prevents simulation to the expected threat level. Therefore, in many cases, analytic models and actual testing are combined to provide a reasonable baseline from which to estimate a system's survivability. NBC contamination survivability validation has been performed on very few systems, and specific test methods and procedures have not been developed for a variety of systems. However, it is known that in many cases, resource limitations and regulatory constraints prohibit the use of live agents. In these cases, simulants may be used in testing although careful attention must be given to the choice of simulant. The materials used to construct a system must be analyzed in conjunction with the proposed simulant to ensure that the properties of wettability, sorption, and chemical reactivity closely resemble those that would occur in actuality.

5.3 Test Planning

5.3.1 Test planning is required as an integral part of the acquisition process. Current Army policy states that the AS will not be approved without a test plan. This planning begins with preparation of the Test and Evaluation Master Plan (TEMP) during the CE Phase.

5.3.2 During development of the O&O Plan, System Program Issues (SPI) such as operational effectiveness and suitability, affordability, producibility risks, costs, scheduling, etc. are surfaced. From these SPI, the System Test and Evaluation Critical Issues (STECI) are obtained. The STECI are determined by the CBTDEV, MATDEV, independent evaluators, and Test Integration Working Group (TIWG) members. Independent evaluators are established to provide objective assessment of the system, force structure, and employment concept. The TIWG is chaired by the responsible MATDEV and provides coordination and integration of testing activities. Once the STECI are established, the draft TEMP is prepared. The TEMP is a summary document, outlining the overall test and evaluation scenario which includes rationale for the kind, amount, and scheduling of the planned testing, to include survivability testing.

5.3.3 The Independent Evaluation Plans (IEPs) are prepared by the independent evaluators and identify the evaluation issues, taken from the TEMP, to be addressed by UT/TT or by other means, such as modeling/simulation. Two IEPs are developed, one to serve as the guide for UT and a second to guide TT. From these two documents, the associated Test Design Plans (TDPs) are developed. These TDPs provide conditions, data requirements, and test events necessary to establish compliance with specifications.

5.3.4 The Detailed Test Plan (DTP) is based on the TDP and provides an explicit description of the execution of the tests. This document addresses the purpose, objectives, and scope of the tests. It reflects planning on matters of test control, environments, data collection, analysis, and administrative aspects of test operations such as dates, locations, resource requirements, and costs. The DTP for nuclear survivability testing is requested via the DID DI-R-1759A, "NWE Test Plan" and for NBC contamination via the DID DI-R-1779, "NBC Contamination Survivability Test Plan." The MATDEV's contractor is required to write the DTP and to execute the tests. The contractor bases the plan on the TEMP, the TDP, and the contract's SOW. In the event TECOM is to perform the tests, then TECOM writes the DTP. In all cases, specific requirements and conditions for tests must be included in the final version of the DTP and in the test data analysis. However, the initial version of the document cannot contain all of the details called for in the TDP because such information is not available at that point in the acquisition process. Many of the details are included in follow-up versions after contract award and contractor/government discussions in the TIWG.

5.3.5 The nuclear/NBC contamination survivability experts, which make up part of the members of the TIWG, play an important role with regard to system survivability. This role includes preparing inputs to planning documents (i.e., the TEMP, TDP, and DTP), evaluating contractor test plans and reports, ensuring that validation tests are conducted in conformance with the test plan (a formal responsibility of TECOM), and providing information on survivability test issues.

5.3.6 Nuclear/NBC contamination survivability expertise is required by the MATDEV in addition to participation on the TIWG. The MATDEV Program Management Office (PMO) requires support to effectively monitor contractor plans and progress and to ensure that validation tests are adequate. The survivability experts are appointed by the PMO and should be independent of the organizations that are developing the equipment and performing the tests and/or evaluations. In order to ensure that the NWE experts are able to provide maximum impact, the appointments should occur prior to contract award. They are expected to provide inputs to the RFP, evaluate proposals, monitor contractor hardening approach, review the test data, and assess vulnerability predictions throughout the acquisition process. The nuclear expertise in question can be obtained from the NEST and others in the HDL located at Adelphi, Maryland, while NBC contamination expertise can be found in CRDEC, Aberdeen, Proving Ground, Maryland.

5.4 Test Schedules

5.4.1 Submittal of the DTP is required by the CDRL unless TECOM is the tester. The schedule for the DTP is then agreed to between the PMO and TECOM. It is important that the Government require an early submittal of the DTP to allow sufficient time for a detailed review. A minimum of 120 days before the tests is desirable, and 150 days might be necessary for complex systems. A long lead time permits revisions and an optional second Government review in case of significant problems detected in the first review and if an alternate simulation facility must be located.

5.4.2 To develop reliable test plans, the contractor needs to understand the sophistication of survivability tests and the performance effort required. Test facilities are often fully scheduled and test execution delays often occur. Worse case estimates of effort required in test execution should be utilized to ensure that a complete test plan is performed. The test plan should list tests in priority order to be able to choose less important ones if some have to be cancelled. Contractors should be aware that some test facilities may require a test plan in advance of scheduled tests. Any equipment which contains flammable, toxic, radioactive, or other hazardous materials requires special review and approval by the test facility safety committee. The contractor should make orientation visits to the test facilities to learn about special characteristics which can affect the test plan.

SECTION 6. CONCLUSION

6.1 In order to minimize cost parameters, survivability should be addressed early in a system's life cycle as late incorporation can have a serious detrimental impact on cost and production schedules. Engineering design, analyses, and testing in the development stages, combined with an effective assurance program in the production stage, will complete a successful survivability program.

6.2 Consultation with the agencies listed below is necessary in the formulation of comprehensive nuclear and NBC contamination survivability programs.

6.2.1 United States Army Nuclear and Chemical Agency (USANCA) - USANCA provides the Director for the Nuclear and Chemical Survivability Committee Secretariat (NCSCS) which acts as the reviewing, coordinating, and recommending body to the Nuclear and Chemical Survivability Committee (NCSC). The NCSCS offers technical support and advice in the review of requests for modification or waiver of survivability criteria. In addition, USANCA assists the materiel developer by establishing hardening criteria; maintaining liaison and information exchange with federal agencies to constantly update evolving policies, plans, and procedures; assisting all affected agencies in correcting unsafe nuclear or chemical conditions; maintaining initial NWE and NBC contamination databases; and publishing related literature.

Address:	Commander USANCA ATTN: MONA-NU/CM 7500 Backlick Road, Bldg 2073 Springfield, VA 22150-3198	
Points of Contact:	Dr. Davidson (Technical Director) MAJ O'Shaughnessy (NWE Hardening Criteria) LTC Kelly/Mr. Soliven (NBC Contamination Survivability Criteria)	
Phone Numbers:	Dr. Davidson -	(703) 355-7276 AV345-7276
	MAJ O'Shaughnessy -	(703) 355-7256 AV345-7256
	LTC Kelly/Mr. Soliven -	(703) 355-7271 AV345-7271

6.2.2 Nuclear Effects Support Team (NEST) - NEST assists the materiel developer in NWE-specific issues. NEST is experienced in assisting in the preparation of RFPs and SOWs, providing members to SSEBs and Design Reviews, producing technical data and documentation on NWE, and coordinating test procedures.

Address:	Director Harry Diamond Laboratories ATTN: SLCHD-NW-P 2800 Powder Mill Road Adelphi, MD 20783-1197
Point of Contact:	NEST Leader - Roland Polimadei
Phone Number:	(301) 394-2856

6.2.3 Chemical Research, Development, and Engineering Center (CRDEC) - CRDEC assists the materiel developer in specific issues with regard to NBC contamination. CRDEC is capable of providing assistance similar to NEST, but from the NBC contamination perspective.

Address:	Commander Chemical Research, Development, and Engineering Center ATTN: SMCCR-NB Aberdeen Proving Ground, MD 21010-5423
Point of Contact:	Dr. William S. Magee, Jr.
Phone Number:	(301) 671-3420/3090 AV 584-3420/3090

6.2.4 U.S. Army Medical Materiel Development Activity (USAMMDA) Nuclear Survivability Advisor - This individual is the point of contact between USAMMDA, the contractors, and the technical agencies (CRDEC and NEST) who provide advice on nuclear and NBC contamination matters for Product Management Officers within USAMMDA and contractors.

Address:	Commander USA Medical Materiel Development Activity ATTN: SGRD-UMA (Dr. Caldwell) Ft. Detrick, Frederick, MD 21701-5009
Point of Contact:	Dr. D. Caldwell
Phone Number:	(301) 663-7571 AV 343-7571/7418

APPENDIX A

BIBLIOGRAPHY

RELATED MATERIAL

BIBLIOGRAPHY

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APPENDIX B

ACRONYMS

ACRONYMS

AEP	Allied Engineering Publication
AMC	Army Materiel Command
AR	Army Regulation
Bq	Becquerel
cal/cm^2	calories per square centimeter
CBTDEV	Combat Developer
CDRL	Contract Data Requirements List
CE	Concept Exploration
CFE	Contractor-Furnished Equipment
CFP	Concept Formulation Package
cm	centimeter
CPE	collective protection equipment
CRDEC	Chemical, Research, Development, and Engineering Center
DID	Data Item Description
DOD-STD	Department of Defense Standard
DTP	Detailed Test Plan
ECP	Engineering Change Proposal
EMP	electromagnetic pulse
ERRIC	Electronics Radiation Response Information Center
FOT&E	Follow-On Test and Evaluation
g/m^2	grams per square meter
GFE	Government-Furnished Equipment
HEMP	high altitude electromagnetic pulse
HCI	hardness critical items
HDL	Harry Diamond Laboratories
IEP	Independent Evaluation Plan
INR	initial nuclear radiation
MATDEV	Materiel Developer
MeV	megaelectron volt
mm	millimeters
n/cm^2	neutrons per square centimeter
NBC	Nuclear, Biological, and Chemical
NCSC	Nuclear and Chemical Survivability Committee
NEST	Nuclear Effects Support Team
NSDA	Nuclear Survivability Design Advisor
NWE	Nuclear Weapons Effects
O&O	Operational and Organizational
PIP	Product Improvement Program
PQT	Production Qualification Test
psi	pounds per square inch
QPL	Qualified Products List
QSTAG	Quadripartite Standardization Agreement
rad	radiation absorbed dose
RFP	Request For Proposals
RHA	radiation hardness assurance
sec	second
SGEMP	system-generated electromagnetic pulse
Si	silicon
SPI	System Program Issues
SOW	Statement of Work
SSEB	Source Selection Evaluation Board
STECI	System Test and Evaluation Critical Issues
TDP	Test Design Plan
TECOM	Test and Evaluation Command

TEMP	Test and Evaluation Master Plan
TIWG	Test Integration Working Group
TRADOC	Training and Doctrine Command
TT	Technical Test
USANCA	U.S. Army Nuclear and Chemical Agency
UT	User Test

APPENDIX C

GLOSSARY

GLOSSARY

Abbreviated Analysis (AA) - The document which compares the means of solving deficiencies associated with; confirms requirements for; estimates the Life Cycle Cost of; and estimates benefits relative to the cost of; a new program. Similar, but in less detail, to a Cost Operational Effectiveness Analysis (COEA) which is generally associated with larger acquisition efforts. The AA or COEA is part of the CFP.

Academy of Health Sciences, U.S. Army - The CBTDEV for the U.S. Army Health Services Command.

Acquisition Strategy (AS) - The conceptual framework for conducting materiel acquisition, encompassing the broad concepts and objectives which direct and control the overall development, production, and deployment of a materiel system. It evolves in parallel with the system's maturation.

air-blast - The shock wave produced in the air or on the Earth's surface, as a result of a nuclear detonation; also referred to as blast.

Army Materiel Command (AMC), U.S. - The Army's principal Materiel Developer; responsible for Army-wide implementation of research, development, test, and evaluation as well as provide acquisition and logistics support for assigned materiel.

balanced hardening - The concept of evaluating the typical threat levels for a piece of equipment, given its mission, deployment scenario, and governing doctrine, and weighing those levels against the ability of a soldier to survive in that environment.

Best Technical Approach (BTA) - The document which compares the means of solving deficiencies associated with; confirms requirements for; estimate the Life Cycle Cost of; and estimates benefits relative to the cost of; a new program.

blast - see air-blast.

chemical agents - The category of NBC warfare that contains chemical agents designed to kill, seriously injure, incapacitate, temporarily irritate, or disable man through physiological effects.

chemical reactivity - The characteristic describing the level and intensity of molecular interaction a chemical typically exhibits.

biological agents - The category of NBC warfare that contains microorganisms and toxins that cause disease in man, plants, and animals.

Chemical Research, Development, and Engineering Center (CRDEC), U.S. Army - Agency established by the Army Materiel Command (AMC), CRDEC has set up a technical assistance program to support materiel developers on preparing Requests for Proposals and Statements of Work and by participating on Source Selection Evaluation Boards and at Key Design Reviews. CRDEC support also includes: the preparation of handbooks; the preparation and maintenance of materials and simulants data bases; the development of models, military hardware, and product improvement hardware; and chemical agent testing of materials and components.

collective protection equipment (CPE) - An enclosure, employing positive pressure and filters, that provides a contamination-free environment.

Combat Developer (CBTDEV) - Command or agency that formulates doctrine, concepts, organization, materiel requirements, and objectives. Represents the user community in the materiel acquisition process.

compatibility - The ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC protective ensemble is termed "compatibility." Even if a piece of equipment is completely hardened against NBC contamination and decontaminants and can also be easily decontaminated, it still must have the capability of being operated effectively while in an NBC contaminated environment. Thus, in the development of equipment designed to perform mission-essential functions one must consider the combination of the equipment and anticipated NBC protection.

Concept Evaluation Program (CEP) Test - Innovative tests conducted with developing command controlled funds, personnel and equipment to provide information on the operational feasibility of a concept or system.

Concept Exploration (CE) Phase - The initial phase of the Army materiel acquisition process in which all possible alternatives are identified and explored; the necessary information for selecting the best alternatives for system concepts and hardware or software is acquired; and an acquisition strategy is developed.

Concept Formulation Package (CFP) - Summarizes the results of the Concept Exploration (CE) Phase and establishes the technical and economic specifications for a product; consists of the Trade-Off Determination (TOD), Trade-Off Analysis (TOA), Best Technical Approach (BTA), and either a Cost Operational Effectiveness Analysis (COEA) or Abbreviated Analysis (AA).

Contract Data Requirements List (CDRL) - A list including all data items that are to be delivered under a contract; lists all essential data and includes a delivery schedule.

Cost Operational Effectiveness Analysis (COEA) - See Abbreviated Analysis.

current injection test - Type of electromagnetic pulse (EMP) simulation testing in which a system is directly driven by simulated threat levels.

Data Item Description (DID) - A set of instructions specifying how items in the Contract Data Requirements List (CDRL) are to be prepared and what they should contain.

decontaminability - The ability of a system to be decontaminated to reduce the hazard to personnel operating, maintaining, and resupplying the system. The key to the definition is the requirement to reduce the hazard to personnel.

Demonstration and Validation Phase - The second phase in the Army materiel acquisition process in which the system concept, as expressed in the Concept Formulation Package (CFP) is verified and described in the Operational and Organizational (O&O) Plan or the Joint Services Operational Requirement (JSOR); trade-off proposals are analyzed; problems identified in the Concept Exploration Phase are resolved or minimized; and the requirements document is updated.

Detailed Test Plan (DTP) - A set of explicit instructions for affecting every phase of the test, particularly test control, data collection, and analysis.

Development Proveout Phase - The second phase of the streamlined acquisition process, analogous to a combination of the later stages of the Full Scale Development Phase with some initial production phase activities. (See Full Scale Development Phase).

electromagnetic pulse (EMP) coupling - The process through which an external current or voltage source attaches to a piece of equipment.

electromagnetic pulse (EMP) - Electromagnetic energy produced when the gamma rays released during a nuclear detonation interact with the atmosphere or other materials to produce electrons and positive ions. EMPs produce large currents on deliberate or nondeliberate antennas, which can result in component burnout or upset.

Engineering Change Proposals (ECPs) - Proposal to change design or engineering features of materiel under development or production. Includes proposed engineering change and documentation by which the change is described and suggested.

fallout - Upon nuclear detonation, radiologically contaminated surface material and physical weapon debris get entrapped in the uprising afterwinds; subsequently, these radioactive particles (the fallout) descend back to the surface of the Earth.

Follow-On Test and Evaluation (FOT&E) - Test and evaluation conducted subsequent to the full production decision to obtain information lacking from earlier initial operational test and evaluation.

Full Scale Development Phase - The third phase in the Army materiel acquisition process in which the system and all necessary support items are developed and designed; engineering development prototypes are developed; and the capability, producibility, operational suitability, and logistic supportability of the completed design are analyzed.

gamma rays - Gamma rays of high energy electromagnetic radiation (photons) which accompany nuclear transitions and are typically in the energy range of 0.01 to 10 MeV. Those from nuclear bursts have an energy (well away from the fireball) of about 1.5 MeV. Gamma rays are very penetrating and require that a considerable amount of dense shielding material be used. Low energy gamma rays are physically identical to high energy x-rays except that the latter are produced in orbital electron transitions rather than in nuclear transitions. Those gamma rays associated with INR are referred to as prompt gamma rays and are produced directly in a nuclear burst, with a pulse which has a rise time of several nanoseconds (10^{-9} sec) and a decay time of a few tens of nanoseconds (ns).

hardness critical item (HCI) - An HCI is an item of hardware or software which satisfies one or more of the following rationales:

1. Functionally required hardware (i.e, hardware included in equipment design to accomplish any engineering requirement other than nuclear hardening) whose response to the specified nuclear environments would cause a degradation in equipment survivability unless additional provisions for hardness are included in item specification, design manufacture, item selection process, etc.

2. Functionally required hardware that inherently provides protection for the equipment or any of its elements against the specified nuclear environments, and which if removed or replaced by an alternate functional design, could cause a degradation in equipment survivability.

3. Hardness dedicated hardware or software included in equipment design solely to help satisfy the specified hardness requirements.

4. Hardware items (at the level of application) to which a hardness critical process is applied.

5. A subassembly or higher level of assembly which contains one or more HCIs.

hardness margin - A hardness design margin is a numerical measure of the hardness of a given hardware element, usually expressed as the ratio of the level of hardness attributed to the hardware element with respect to the specified hardness requirements assigned or allocated to that hardware element. The level of hardness attributed to a hardware element is usually based on specific tests, analytical results, or the application of relevant material/component characteristics data published in appropriate sources.

hardness - The ability of a system to withstand a hostile environment and maintain its ability to complete the designated mission. NBC contamination hardness includes the ability to withstand both the damaging effects of contamination and decontamination. Nuclear hardness involves the ability to withstand the assigned nuclear threat levels.

Harry Diamond Laboratories (HDL), U.S. Army - One of the seven research development laboratories for the U.S. Army Laboratory Command (LABCOM); HDL is responsible for basic and applied research, exploratory and advanced development, and technology leadership in nuclear survivability and other high technology matters.

high altitude electromagnetic pulse (HEMP) - The electromagnetic pulse resulting from a nuclear burst at a height of 40 km or greater. This type of EMP is dangerous in that it can illuminate large areas (a 12.5 to 25 mile above-Earth burst could effect the entire United States).

Independent Evaluation Plan (IEP) - A document that defines the methodology by which independent evaluators assess a system's ability to meet requirements.

initial nuclear radiation (INR) - The radiation which illuminates an area for the period of beginning at the instant of a nuclear detonation and continuing for one minute; consists primarily of prompt x-rays, prompt gamma rays, secondary gamma rays, fast neutrons, and thermal neutrons.

initial nuclear weapons effects (NWE) environment - The environment resulting initially and enduring for one minute following a nuclear weapon detonation; composed of initial nuclear radiation (INR), thermal radiation, blast, and electromagnetic pulse (EMP). Also referred to as the nuclear environment.

Integrated Logistic Support (ILS) - A composite of all support considerations necessary to the effective and economical support of a system at all levels of maintenance for its programmed life cycle.

Joint Services Operational Requirement (JSOR) - A statement of need for the same end item to be used by more than one military service.

Laboratory Command (LABCOM), U.S. Army - One of the subordinate commands of the U.S. Army Materiel Command (AMC); LABCOM is the major technical research and development support agency for AMC.

Logistic Support Analysis - An analytical technique used by integrated logistic support management to provide a continuous dialogue between designers and logisticians. LSA provides a system to identify, define, analyze, quantify, and process logistics support requirements for materiel acquisition programs. (Reference MIL-STD 1388-1A).

Logistic Support Analysis Record - File of logistic support information in standardized format, on acquisition programs for specific new or modified systems and equipments. Serves acquisition process using logistic data derived during all phases of the process to support logistic support analysis processes. (Reference MIL-STD 1388-2A).

low-altitude electromagnetic pulse (LEMP) - The term used to describe bursts on or near the Earth's surface in which very strong electromagnetic fields illuminate relatively small regions.

Product Improvement Program - An effort to incorporate a configuration change involving engineering and testing on end items and depot-repairable components; or any effort on items, other than those which are developmental, to increase efficiency or extend the lifetime.

Materiel Developer (MATDEV) - Agency responsible for research, development, and production validation of a system in response to approved requirements. MATDEVs also conduct technical testing.

mission-essential materiel - Equipment that is necessary to accomplish battlefield missions of the unit or organization.

NBC (nuclear, biological, and chemical) contamination environment - The environment resulting from the exposure to any or all of the following; chemical/biological warfare agents and residual nuclear radiation (RNR) (fallout, rainout, and neutron-induced gamma activity).

NBC contamination survivability criteria - A quantified description of the conditions that define decontaminability, hardness, and compatibility; these standards are outlined in U.S. Army Nuclear and Chemical Agency's (USANCA) Department of Army Approved NBC Contamination Survivability Criteria for Army Materiel.

NBC contamination survivability requirement - The selection of characteristics for which the NBC contamination survivability criteria apply constitute the survivability requirement.

NBC contamination survivability - The capability of a system and its crew to withstand an NBC contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. NBC contamination survivability is composed of three characteristics: (1) decontaminability, (2) hardness, and (3) compatibility.

NBC protective ensemble - Clothing specifically design to protect the soldier and allow for safe operation in an NBC contaminated environment; also referred to a Mission-Oriented Protective Posture (MOPP).

neutron fluence - The concentration of neutrons per given area, typically measured in neutrons per square centimeter.

neutron-induced gamma activity - Radioactivity induced in the ground or in an object as a result of direct-irradiation by neutrons.

nuclear (initial NWE) survivability criteria - The set of threat levels, defined by USANCA (using the balanced survivability concept), to which a piece of equipment must be survivable.

nuclear (initial NWE) survivability - The capability of a system to survive the initial effects of a nuclear detonation and still accomplish its designated mission, at a level acceptable to the user. Nuclear survivability is accomplished through one or a combination of, the following methods:

> Hardening - Hardening refers to the use of design techniques that increase the ability of equipment to withstand exposure to one or more effects of man-made hostile environments.
>
> Avoidance - Achieve survivability by using mobility, concealment, and deception.
>
> Mitigation - Achieve survivability by field expedient techniques readily accomplished using only what is available. Will not correct vulnerability, but may reduce its consequences.
>
> Reconstitution - Achieve survivability by possessing the ability to repair or replace on the battlefield a timely manner which permits mission achievement.

Proliferation - Achieve survivability by deploying so many systems or components on the battlefield that the loss of a few will not preclude mission completion.

Nuclear and Chemical Survivability Committee (NCSC), U.S. Army - The NCSC establishes policies implementing the intent of AR 70-60 and AR 70-71 to ensure a coordinated survivability program throughout the materiel life cycle. The NCSC establishes staff and agency survivability-related responsibilities.

Nuclear Effects Support Team (NEST), U.S. Army - An organization sponsored by the U.S. Laboratory Command (LABCOM) which is responsible for transferring nuclear vulnerability, survivability, and hardening technologies. NEST is capable of providing assistance in Request for Proposal and Statement of Work preparation, providing members to Source Selection Evaluation Boards and Design Review, producing technical data and documentation on nuclear weapon effects, and coordinating testing activities.

Nuclear Survivability Design Advisor (NSDA) - An automated data processing application which addresses the technical aspects of incorporating hardness to weapon effects into system design. The NSDA provides assistance in responding to the nuclear survivability Data Item Descriptions and helps analyze a system's nuclear survivability.

nuclear survivability requirement - The method(s) chosen to achieve nuclear survivability (i.e., hardening, redundancy, resupply, mitigation, or avoidance).

Organizational and Operational (O&O) Plan - The primary program initiation document; describes how and where a product will be integrated into the force structure, deployed, operated, and supported in peace and wartime.

peak gamma dose rate - The speed at which gamma rays illuminate an area; for testing of semiconductors, the peak gamma dose rate is measured in rads(Si) per second.

Preproduction Qualification Test (PPQT) - A test of the first or one of the first produced items or groups of items being procured; conducted to verify the adequacy and quality of the materiel when produced according to production drawings and the mass production process.

Production and Initial Development Phase - The final phase in the Army materiel acquisition process in which equipment is acquired and distributed; personnel and units are trained; and logistic support is provided.

Production Qualification Test (PQT) - Tests run on lots of production items to verify that the adequacy and quality of materiel have been maintained throughout the production process.

Proof of Principle Phase - The initial phase of the streamlined acquisition process, analogous to a combination of the Concept Exploration Phase and Demonstration and Validation Phase of the system acquisition process. (See Concept Exploration Phase and Demonstration and Validation Phase).

Quadripartite Standardization Agreement (QSTAG) - A document that defines agreement to a standard, by the United States, Canada, Great Britain, and Australia.

radiation hardness assurance (RHA) - The term used to describe items that have been tested and are guaranteed to satisfy neutron fluence and total dose hardening criteria.

rainout - A special type of fallout, initially produced by the same mechanism but are distributed over the Earth through the influence of precipitation.

Requests for Proposal (RFP) - A document which is used to solicit proposals from the contracting community, initiates the competitive procurement process.

Required Operational Capability (ROC) - The primary requirements document which concisely states the minimum essential operational, technical, logistic, and cost information necessary to enter Full Scale Development.

residual nuclear radiation (RNR) - Radiation existent following the one-minute period after a nuclear detonation; contaminates an environment through fallout, rainout, and neutron-induced gamma activity.

solubility - The characteristic describing the degree to which a contaminant or simulant can penetrate given surface; sorption is strongly related to molar volume and molecular weight. Also referred to as sorption.

Source Selection Evaluation Board (SSEB) - Committee which examines requirements, facts, recommendations, and Government policy relevant to a competitive procurement award decision and subsequently makes the decision.

Statement of Work (SOW) - A document describing the work to be performed or services to be rendered, defines the respective responsibilities of the Government and contractor, and provides objective measures by which to judge fulfillment of the requirement.

system acquisition process - Method by which a new or improved capability is developed in response to a stated mission need or deficiency. The standard Army acquisition process consists of the following phases: Concept Exploration, Demonstration and Validation, Full Scale Development, and Production and Initial Deployment Phase.

system-generated electromagnetic pulse (SGEMP) - System-generated electromagnetic pulse (SGEMP) consists of the electromagnetic energy generated by the interaction of nuclear ionizing radiation with equipment hardware. SGEMP is produced by nuclear radiation, particularly x-rays and gamma rays, interacting directly with the system itself. For a system at low altitudes, the system must be close to the weapon for these interactions to be significant, so SGEMP is relevant only for systems sufficiently durable to withstand severe nuclear environments. Since SGEMP is generated by the system, the fields and current depend on the size, shape, structure, and composition of the system in a complex way. There is therefore no standard SGEMP waveform. The environments are very severe; field amplitudes larger than a million volts per meter (1 MV/m) are possible in some cases.

Technical Feasibility Testing (TFT) - The testing by the materiel developer to provide test data for a technical evaluation and assessment of items and/or systems developed by another service, a foreign nation or a commercial firm.

Technical Testing (TT) - Testing of materiel systems conducted by the materiel developer using the principle of a single, integrated development test cycle to demonstrate that the design risks have been minimized, that the engineering development process is complete, and that the system will meet specifications; and to estimate the system's military utility when it is introduced.

Test and Evaluation Master Plan (TEMP) - A document used in the Army review and decision process to assess the adequacy of planned testing and evaluation and is prepared for all defense system acquisition programs. The TEMP is a broad plan that relates test objectives to required system characteristics and critical issues and integrates objectives, responsibilities, resources, and schedules for all test and evaluation to be accomplished.

Test Design Plan (TDP) - A formal document developed by the test organization which states the circumstances under which a test and/or evaluation will be executed, the data required from the test, and the methodology for analyzing test results.

Test Integration Working Group (TIWG) - A formally chartered organization chaired by the materiel developer and having as a minimum, membership representatives (with authority to act for their respective commands/activities) from the combat developer, the logistician, the operational tester, the materiel developer and, when appropriate, the contractor. The primary purpose of the TIWG is to provide a forum for direct communication to facilitate the integration of test requirements and speed up the Test and Evaluation Master Plan (TEMP) coordination process. The objective of the TIWG is to reduce costs by integrating testing to the maximum extent; eliminating redundant testing, and facilitating the coordination of test planning, interchange of test data, and use of test resources to achieve cost-effective testing.

The Surgeon General - Monitors the life cycle management of Army medical materiel, assesses the health hazards of materiel, and investigates the medical aspects of non-medical Research, Development, Test and Evaluation. Also develops policy, procedures, and responsibilities for acquisition of medical materiel.

thermal radiation - The energy released in the form of heat and light, upon nuclear detonation; consists of ultraviolet, visible, and infrared radiation.

Trade-Off Analysis (TOA) - The document which establishes mission and performance envelopes for; analyzes system trade-offs of risks, capabilities, costs, schedule, manpower, and support associated with; and selects the best technical approach for the implementation of; a new program. The TOA is part of the CFP.

Trade-Off Determination (TOD) - The document which establishes the feasibility of; identifies the technical risks associated with; estimates the life cycle cost and acquisition schedules for; and describes the technical approach used in; a new program. The TOD is part of the CFP.

Training and Doctrine Command (TRADOC), U.S. Army - The principal CBTDEV for the Army; also responsible for the formulation of Army-wide doctrine, concepts, organization, materiel requirements, and objectives.

U.S. Army Nuclear and Chemical Agency (USANCA) - USANCA is a field operating agency of the Deputy Chief of Staff for Operations and Plans, whose responsibilities include: advising and assisting Government agencies on the matters of chemical and nuclear weapons, publishing related literature, and identifying and recommending Army requirements and priorities for nuclear and chemical weapons effects research. USANCA provides a member to the Nuclear and Chemical Survivability Committee (NCSC).

United States Army Medical Materiel Development Activity (USAMMDA) - The Army agency, operating under the Surgeon General, having principal Materiel Developer responsibilities.

User Testing (UT) - Testing of materiel systems conducted with typical users in the environment and organization in which it is to be deployed.

wettability - The characteristic describing the degree to which a contaminant or simulant can penetrate a given surface; wettability is strongly related to contact angle and surface tension.

APPENDIX D

NUCLEAR WEAPONS EFFECTS (NWE)

APPENDIX D

NUCLEAR WEAPONS EFFECTS (NWE)

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SECTION 1. INTRODUCTION

The purpose of this appendix is to present fundamental nuclear weapons effects (NWE), hereafter referred to as simply "nuclear effects", information intended to be of assistance to the materiel developer and contractors in the development of Army equipment hardened to specified nuclear hardening criteria. These hardening criteria are specified by U. S. Army Nuclear and Chemical Agency (USANCA) based on information provided by the combat developer. The materiel developer accepts the hardening criteria and attempts to meet them as resources and state-of-the art technology permits. In the event nuclear hardening cannot be incorporated in the design, then operational procedures must compensate for or mitigate the deficiency. The materiel developer is expected to assist the combat developer in making trade-off determinations regarding designed-in materiel capabilities versus modifying operational procedures.

SECTION 2. NUCLEAR ENVIRONMENTS

2.1 Phenomenology

Nuclear environments are technically defined as the various induced stresses imposed on equipment as a result of the detonation of a nuclear weapon. These stresses are created both as a direct consequence of nuclear interactions within the explosive material and interactions of weapon products with the atmosphere, the earth and equipment materials. The four categories of environments are initial nuclear radiation (INR), electromagnetic pulse (EMP), thermal radiation, and air-blast.

For a specific nuclear detonation, the distribution of the total energy of the weapon (measured in kilotons of trinitrotoluene(TNT)) depends on height of burst from the earth's surface and weapon design. For a relatively low altitude of burst, the distribution of energy for a typical tactical nuclear weapon is as follows: INR, 5 percent; thermal radiation, 35 percent; air blast, 50 percent; and residual radiation, 10 percent. In contrast, there are radiation enhanced designed weapons in which as much as thirty percent of the energy is distributed toward INR with corresponding reductions in the other environments.

Initially, approximately 85 percent of the energy is in the form of x-rays which are quickly absorbed in short distances from the center of burst. This absorption generates an extremely hot and incandescent spherical mass of air and gaseous weapon debris referred to as the fireball. This radiating fireball is the source of the thermal radiation pulse. The fireball compresses the air at its outer surface as it expands thus creating a high density shock front. Eventually, the shock front separates from the fireball and expands outward at a high rate of speed, thus constituting the air-blast environment. Since the density of the atmosphere is an important factor in the development of the fireball and the shock front, the distribution of energy changes as the height of burst is increased. Due to the reduction in the ambient air density as the burst height is increased, the trend is toward a greater portion of the energy resulting in x-ray ionization effects and less in air-blast and thermal radiation. The EMP is a pulse of electromagnetic radiation generated by the interaction of the gamma ray pulse with the earth's atmosphere. Details with regard to EMP are presented below.

For specific targets located a distance from the center of burst, the arrival times and durations of these environments vary with weapon yield, atmospheric conditions, and distance. Essentially however, the various environments arrival at a target at distinct different times as depicted in Figure D1, which is representative of a low altitude burst. The gamma pulse and the generated EMP reaches a target within 10 microseconds, while the neutron pulse, due to a relatively slow speed, has an arrival time within 50 and 100 microseconds. The thermal radiation pulse, which is generated by the fireball much later, has an arrival time greater than 100 milliseconds after the detonation, while the air blast arrival time is greater than one second. This separation of arrival times simplifies the task of simulating the various NWE environments.

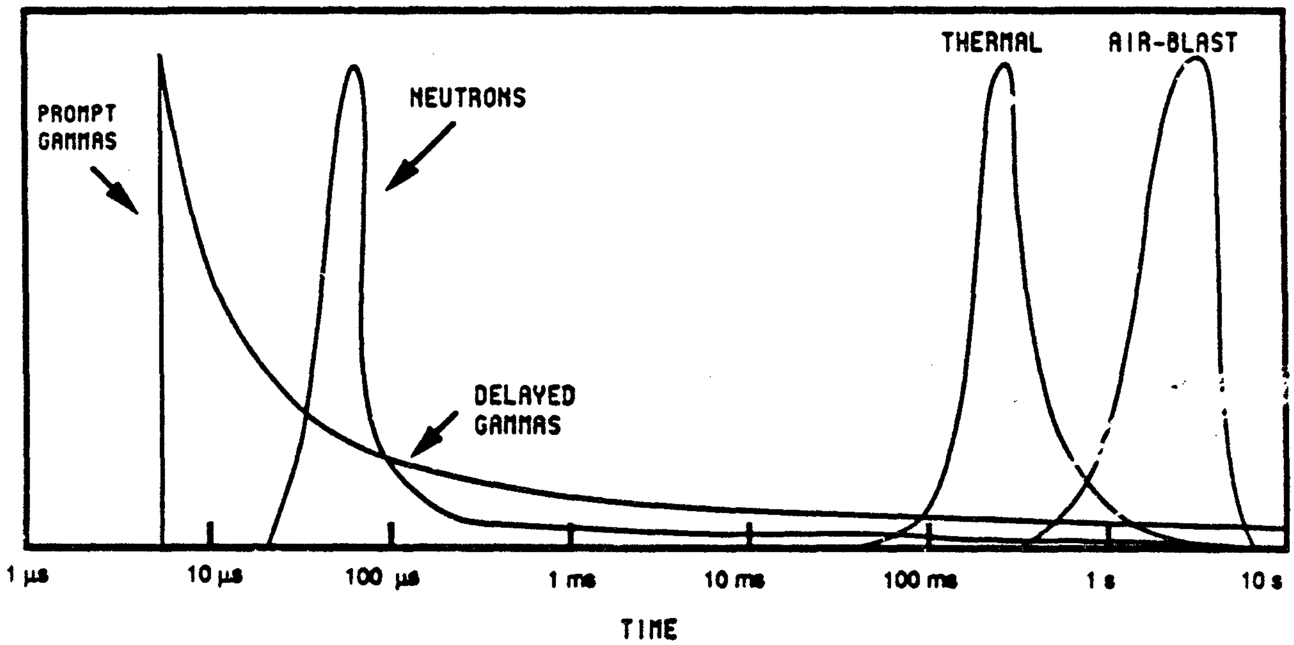

Figure D1: Components of the Nuclear Environment Arrival Times for Low Altitude Bursts

2.2 Initial Nuclear Radiation (INR) Environment

The INR environment consists of atomic and nuclear particles and photons emanating directly from a nuclear detonation or from subsequent interactions of this radiation with the surrounding media. The important nuclear radiations from a nuclear hardening standpoint include prompt x-rays, prompt gammas, secondary gammas, fast neutrons, and thermal neutrons. However, for the purposes of this Appendix only the fast neutrons and prompt gamma rays will be discussed.

The gamma ray environment consists of high energy electromagnetic radiation (photons) which accompany nuclear transitions and which are typically in the energy range of 0.01 to 10 MeV. Those from nuclear bursts have an energy (well away from the fireball) of about 1.5 MeV. Gamma rays are very penetrating and for practical shielding require that a considerable amount of dense shielding material be used. Low energy gamma rays are physically identical to high energy x-rays except that the latter are produced in electron orbital transitions rather than in initial nuclear transitions. The prompt gamma ray pulse has a rise time of several nanoseconds (10^{-9} sec) and a decay time of a few tens of nanoseconds. The two important parameters pertaining to the gamma ray pulse, which affect materiel, are gamma dose and the gamma dose rate.

The neutron environment consist of uncharged particles (neutrons) generated in nuclear processes that can travel long distances in the atmosphere. The important neutron parameter is the neutron fluence (number/sq. cm).

2.3 Electromagnetic pulse (EMP) Environment

The electromagnetic pulse is a pulse of electromagnetic radiation created as a consequence of a nuclear burst in or above the earth's atmosphere. For a high altitude burst (HAB: height of burst >40km), EMP is caused by gamma ray-generated Compton currents which are deflected by the geomagnetic field, thereby producing strong transverse (radiated) electromagnetic field components which illuminate large areas. For a surface burst, EMP is caused mainly by the asymmetry in the gamma ray-generated Compton current due to the earth's surface, thereby generating strong transverse (radiated) electromagnetic field components over a local coverage area. For a low altitude burst (height of burst between roughly 2 and 20 km), EMP is caused by a slight asymmetry in the gamma ray-generated Compton current due to the air density decrease with height, thereby generating a small effective vertical current dipole which radiates a relatively weak electromagnetic field over a moderate coverage area.

2.3.1 High Altitude EMP (HEMP) Environment

High altitude EMP (HEMP) is generated by gamma rays from a high altitude nuclear burst (above 30 km) interacting with the earth's atmosphere. Those gamma rays moving in the upward direction are of no consequence since the air density in that direction is so low the gamma rays travel great distances before being absorbed. However, those emitted in the downward direction encounter a region where the atmospheric density is increasing. The gamma rays interact with the atmosphere by the Compton effect thus generating a field of free electrons. This field of electrons (deposition or source region) becomes asymmetric due to the varied atmospheric density with height which in itself can cause a radiated EMP. However, in the case of a high-altitude burst, EMP at large distances from the burst can also be caused by a different mechanism. That is, Compton electrons from a high-altitude burst tend to follow curved paths along the earth's geomagnetic field lines and are thus subjected to radial accelerations. This ensemble of turning or spiraling electrons, whose density varies with time, emits coherent electromagnetic radiation. An EMP with a large content of high frequencies is thereby produced which is substantially greater than that contained in EMP arising from local asymmetry. The deposition region, which is the source of the HEMP, is thicker immediately below the burst than at larger distances because the gamma-ray intensity decreases with distance from the burst point. Since these gamma rays pass through air of increasing density, most are absorbed in a layer between altitudes of about 15 to 65 km.

HEMP does not radiate solely in the vertical downward direction, but also radiates from the edges and at other angles. Since the propagation of electromagnetic waves at high frequencies is more or less limited to the line-of-sight path, the effect of the earth's surface on the high-frequency EMP is to extend it to the horizon and not beyond. The lower frequencies, however, will extend beyond the horizon by the diffraction process. Thus, the radius of the HEMP burst effect is determined by the tangent to the earth's surface down from the burst point. This means the radius of the effect can be 1,800 to 2,400 km, depending on the altitude of burst. Within the entire region of HEMP propagation, the peak field intensity is essentially the same (within a factor of two) from the earth's surface up to about 20 km altitude with the exception of a small quiet zone around the burst-point magnetic field line. The peak field intensity can be very large. For a high-yield nuclear detonation, HEMP can have a peak field intensity of 100,000 volts per meter. Also, the frequency spectrum is extremely broad, extending from very low frequencies up to the ultra-high frequencies and beyond.

2.3.2 Low Altitude EMP (LEMP) Environment

As in the case of high-altitude bursts, the source of EMP from low altitude (including surface) bursts is gamma radiation. There are some significant differences, however, in the generation mechanism, particularly those arising from the asymmetry of electron flow. More specifically, for a ground burst, gamma rays travelling in a generally downward direction are readily absorbed in the upper layers of the earth's surface, and there is essentially no charge separation or electric field in this direction. The gamma rays moving upward and outward, on the other hand, produce ionization and charge separation in air, as they leave behind positively-ionized air molecules near the burst point.

The gamma rays interact with the air within a few hundred meters at sea level generating Compton electrons. Each Compton electron and photon may ultimately cause the generation of 30,000 electrons. These electrons, being more mobile than the more massive positive ions, can move out to a large radial distance of 1 to 10 km. This large charge separation leads to a large radial electric field between the burst point and the edge of the ionosphere. The net effect of the generally upward movement of the charges is to generate a horizontal magnetic field. By virtue of Ampere's law, the line integral of the magnetic field around the electron flow is equal to the effective vertical current. In addition, as the electrons tend to move toward the ground through the easiest path to get back to the positive charges left behind, another component of the magnetic field is generated at the transverse plane of the current flow. This component of the magnetic field is also a source of EMP.

The electric field produced by a surface burst is very strong, but the radiated field falls off rapidly with distance ($1/R^3$), at first from the deposition region, and then somewhat less rapidly afterwards ($1/R^2$ and $1/R$). The potential hazard to electric and electronic equipment from LEMP will, thus, be greatest within and near the deposition region, extending to 3 to 8 km, depending on the weapon yield. In this area, the structures in which an equipment is housed may suffer damages, especially from high-yield explosions, unless they are blast resistant.

2.3.3 Internal EMP (IEMP) Environment

When the enclosure wall of a system such as a satellite or a missile is subjected to a very large ionizing environment consisting of gamma rays or x-rays, electrons are emitted from the wall. These electrons can be Compton electrons induced primarily by gamma rays, or photoelectrons produced by x-rays, or both. Although electrons are generated throughout the thickness of the wall as the radiation penetrates the wall material, only the electrons close to the inner surface of the wall have sufficient energy to escape the surface and pass into the space behind the wall. This is because the range of the electrons (that is, the maximum distance they can travel before expending their energies and therefore coming to rest) is very short in solid materials. The electrons emitted from or near the surface wall do not exit the surface in a perpendicular direction, but constitute a distribution of electrons over all possible angles. For each electron emitted, a positive ion is left behind in the wall material and an electric field is produced as a result of the charge separation. This field is referred to as the internal EMP (IEMP) which can affect system operation.

The IEMP field exhibits a Coulomb force that tends to decelerate the electrons. If the space behind the wall is a vacuum or near vacuum, as in the case of a satellite in space, for example, the electrons having sufficient energy to overcome the Coulomb force continues across the void until they strike a solid material. If the material is an electrical conductor, the electrons can flow from the stopping point in the conductor back through the metallic structure to the positive charges left behind in the enclosure wall. If, however, the solid material is a dielectric instead, current flow becomes limited. During the time interval when the electrons are traversing the void, or cavity, between the enclosure wall and the stopping wall, very large, short-duration electromagnetic fields are generated in the cavity. These fields may even be magnified at some point or points inside the cavity due to cavity resonances, depending primarily on the cavity geometry, dimensions, the direction of excitation, and cavity-wall conductivity.

To predict analytically the magnitude of the IEMP effect, it is necessary to utilize an accurate model for predicting the electron emission. Such a model depends on the geometry, direction of the incident radiation, energy spectrum of the radiation, and the type of materials involved. In addition, it is necessary to have a model for predicting the electromagnetic fields produced by these electrons, which requires simultaneous solution of Maxwell's equations with plasma equations.

2.3.4 System-Generated EMP (SGEMP) Environment

In addition to EMP resulting from the interaction of gamma rays from a nuclear explosion with the atmosphere or ground, another mechanism of EMP generation is possible by the interaction of nuclear radiations or ionizations with various solid materials present in electronic systems. Such an EMP is referred to as the system-generated EMP (SGEMP). The generation mechanisms of SGEMP and IEMP are similar. The theory of the mechanism for SGEMP is complex, but can be described in simple terms. First of all, the solid material in an electronic system, or even in the shielding designed to protect the system from the external EMP, contains atoms which are heavier than those present in air. As stated previously, the interactions of gamma rays and high-energy x-rays with the solid material will produce electrons by both Compton and photoelectric effects. These electrons can, in turn, interact with the solid materials to release secondary electrons by ionization. These secondary electrons located close to and on both faces of a solid material, have a velocity component perpendicular to the surface. As a result, an electric field is generated at the surface which constitutes a SGEMP. SGEMP can also be generated if the projected cross-section section of the system is not symmetrical, such that more charge can be lost due to electron emission from one end than another. This results in a large surge current along the vehicle or system enclosure structure which is required to redistribute and equalize the charge distribution over the outside surface.

The SGEMP is most important for electronic components in satellite and ballistic systems, above the deposition region, which would be exposed directly to the nuclear radiations from a high-altitude burst. The SGEMP can also be significant for surface and moderate altitude bursts if the system is within the deposition region but is not subjected to damages by other weapon effects. This could occur for surface systems exposed to a burst of a relatively low-yield explosion, or for airborne systems and bursts of higher yield.

The electric fields generated near the system enclosure walls, by direct interactions of ionizing radiations, can induce electric current in components, cables, ground wires, etc., resulting in large currents and voltages capable of causing damage or disruption, just as with IEMP. Because of the complexity of the interactions that lead to the SGEMP, the effects are difficult to predict.

2.4 Thermal Environment

The thermal environment consists of energy transmitted in the form of ultraviolet, visible, and infrared radiation and it is the consequence of energy emanating from the nuclear fireball. Initially, a 0.1-second duration pulse is generated which account for only about 1 percent of the total thermal radiation; this is followed by a second pulse which carries the remainder of the radiation. About 20 percent of the energy in the second pulse is radiated at t_{max} (time at which the maximum energy flux is felt by a target). By $10t_{max}$, over 80 percent of the energy has reached the target. The spectral characteristic of a thermal pulse is similar to a blackbody at a temperature of about 6,000 to 7,000°K.

2.5 Air-Blast Environment

The air-blast environment is created by the nuclear fireball which pushes and compresses the ambient air as it expands outward resulting in an air-blast wave which continues to expand outward leaving the outer edge of the expanding fireball behind. When the front of the air-blast wave (shock front) reaches a specific point, the overpressure and the dynamic pressure levels essentially jumps from ambient to the values existing in the shock front. The shock front overpressure level is the amount of static overpressure exceeding the ambient pressure. As the air-blast wave propagates in the air away from its source (center of the nuclear detonation), the overpressure at the shock front steadily decreases and gradually declines from the level at the shock front to some lower value back at the center of burst. Later this declination is such that the overpressure at some point behind the shock front becomes negative (less than ambient). The positive portion and the negative portion of the blast wave are referred to as the positive phase and the negative phase, respectively.

The air-blast wave consists of two components which are important loading mechanisms on ground surface targets. One is the shock front overpressure which tends to crush the target (diffraction load) and the second is dynamic overpressure which causes drag effects that tend to tear away exterior components and cause a general displacement of the target, including overturning. The dynamic pressure is associated with the mass motion of the air in the blast wave and is approximately equal to the density of the air times the square of the air velocity.

Also associated with air-blast is the debris environment which consists of entrained material within the nuclear cloud (pebbles, dust, ice). This environment is significant when a target is close to the point of detonation as dust particles behind the stock front increase the dynamic pressure.

SECTION 3. MATERIEL RESPONSE

Materiel response is the term used essentially to define how the equipment is affected by the specific environment. The interest in this regard is to identify the response in terms of transient or permanent damage to the equipment.

3.1 Materiel Response to Initial Nuclear Radiation (INR)

Nuclear radiation produces both permanent and transient effects on equipment.

Materiel response to INR which is important to Army equipment is demonstrated primarily by electronics and depends very much on both the design of the electronic systems and the particular electronic components used. In addition, electronic systems may exhibit different vulnerabilities depending on whether the power is on or off, and whether transient upset will alter mission success. INR can also have a permanent effect on optical refractive and reflective elements as both gamma rays and neutrons can change optical absorption properties. A small loss of transmissivity (darkening) in long fiber optic cables can become a significant problem since the amount of light that can be transmitted by the cable is reduced.

The gamma ray component of the INR may interact with atoms of materials creating free electrons and ionized atoms. This create induced currents which can cause permanent and transient effects. The neutron element of INR may interact with the nucleus of a material and can be absorbed or scattered. In either case, energy of the neutron is released from the affected nucleus as a gamma ray, and can cause residual gamma ray activity and may create permanent changes in the characteristics of the material.

3.1.1 Materiel Response to Gamma Rays

Gamma rays will cause electronic circuits/systems to respond to induced currents which are proportional to the ionizing radiation dose rate, to the total charge released as a result of the energy absorbed, or to some combination of the foregoing. The gamma dose rate can upset the logic states of digital circuits and, in the extreme case, may cause permanent failure (burnout) of semiconductor devices. Under certain conditions, the peak prompt gamma dose rate can produce a SGEMP which compounds the gamma dose rate threat. Dose dependent effects include the permanent damage associated with charge trapping and charge release in insulating materials both in the bulk (e.g., capacitors and transparent materials) and in the interface or surface layers (e.g., metal-oxide semiconductor (MOS) devices and semiconductor/surface passivation layers).

The total gamma dose primarily affects, permanently, the material characteristics of metal-oxide semiconductor (MOS) transistors, quartz crystals and fiber optics. The relatively large amount of gamma dose failure levels existing in the literature indicates that the lowest total gamma dose levels at which failure has been observed are: 100 rad(Si) for fiber optics, 525 rad(Si) for NMOS, 1000 rad(Si) for CMOS, and 2000 rad(Si) for quartz crystals.

The peak gamma dose rate generates currents and voltages in powered circuits which can cause false signals, equipment shut down, logic upset, latchup (devices remain on until power is removed) or component burnout. In the event burnout does not occur, any permanent damage is unlikely since functionality can usually be restored by a reset operation. CMOS devices can latchup at relatively low peak gamma rates, but latchup can be prevented by installing current limiting devices in the circuit. Baseline estimates of peak gamma dose rate vulnerabilities can be made from established component vulnerability levels. For example, NMOS ROM's can upset and silicon-controlled rectifiers can trigger at levels as low as 10^6 rad(Si)/s. Operating bubble memories have been permanently damaged at levels of 5×10^7 rad(Si)/s and latchup in some CMOS, TTL, and linear devices have been observed at levels as low as 10^8 rad(Si)/s. Power transistors in power supplies which use transformers and some low power transistors are subject to burnout if the circuits in which they are located lack sufficient impedance. Burnout could also occur at various other places in electronic equipment such as metalization strips on integrated circuits, lead wires in transistors or integrated circuits, junctions in bipolar transistors and diodes, or gate oxides in field effect transistors (FET's). To conduct an analysis of specific equipment, an examination of the schematics is made to ascertain those components where burnout is possible, and if so to recommend component replacement or the installation of an appropriate current limiting device. In any case, peak gamma dose rate tests are required to assure the total absence of this failure mode. Since radiation effects in electronics caused by the peak gamma rate can only occur if the equipment is turned on, this vulnerability can be circumvented by automatically turning off the equipment during a nuclear event using sensitive detectors and fast switches.

3.1.2 Materiel Response to Neutrons

Displacement damage in semiconductor devices is the primary damage mechanism from neutrons (e.g., reduced gain in a transistor). Of secondary importance are neutron-induced changes in the transmission properties of optical materials, and neutron-induced ionization. Since these damage mechanisms are not generally dose rate-dependent, only the integrated dose and neutron fluence (1MeV equivalent damage in silicon (Si)) are specified for neutrons.

Interest in neutrons is based on permanent changes caused by neutron interactions in electronic materials. The level of these changes depend on the number of interactions occurring, thus neutron fluence is the important parameter. The most vulnerable electronic components are semiconductor devices with predominant effects such as decreases in bipolar transistor current gains, increases of leakage currents in bipolar transistors and diodes, increases in saturation voltages, and changes in junction breakdown voltages. An analysis of specific electronic equipment can be accomplished by utilizing quantitative test data on neutron-induced degradation in components existing in the literature and a circuit description of the equipment to determine the neutron fluence failure threshold. Also, an estimate of baseline neutron vulnerability can be obtained from previous studies of the responses of a large number of pieces of unhardened Army electronic equipment to neutrons. Generally, components which are the most vulnerable to neutrons were found to be power circuits which failed at levels above 3×10^{11}n/sq cm. Neutron hardening generally requires circuit redesign.

3.2 Materiel Response to Electromagnetic Pulse (EMP)

The electric and magnetic components of can cause electronic component damage, logic loss, and transient malfunction. EMP couples with materials and systems to varying degrees. Metal enclosures and frames under certain conditions, cables, and antennas are prime candidates for efficient electromagnetic coupling which can contribute to the generation of large voltage and current transients. Command, control, and communications equipment is potentially vulnerable to EMP because of coupling with antennas and cables and the low threshold for upset and damage. These transients can cause damage to materiel, especially electronic materiel, unless proper EMP protection is employed (e.g., protective circuits and devices, cable filters, electric shielding, and isolation). Semiconductor materials are most susceptible, particularly where their electrical properties and orientation permit efficient coupling of the EMP to the system.

3.3 Materiel Response to Thermal Radiation

Equipment response to the thermal pulse environment created by a nuclear detonation depends on the characteristics of the materials present. The effect of this thermal loading is primarily in the form of the consequential changes commonly associated with very high temperature exposure. A single item of equipment may be composed of a variety of materials such as paints, plastics, plexiglass, fiberglass, metals, and bonding materials each of which has a different rate of dissipating absorbed energy. If a material dissipates heat very slowly with respect to the rate of absorption, then the most influential factor for thermal radiation damage will be the total thermal radiation energy deposited. Conversely, if a material can dissipate heat rapidly with respect to the rate of absorption, then the most influential factor will probably be the time rate of delivery of thermal energy (thermal irradiance). As a consequence, characteristics of both the delivery rate and the total energy delivered must be stated in nuclear hardening criteria.

Certain analytic techniques are available which can enable an analyst to quickly and economically evaluate thermal survivability of Army equipment. Generally, such techniques can be used to extrapolate, interpolate, and interpret experimental data to obtain estimates of thermal response of untested samples and/or environmental levels. One technique consists of the calculation of maximum temperature rise in an exposed material to determine if the exposed material's damage threshold temperature (i.e., the temperature at which a material will melt, weaken or soften, fracture, decompose, char, vaporize, or ignite) has been exceeded. In addition to the phase and chemical changes which occur in materials at elevated temperatures, thermal gradients are accompanied by thermal stresses which can fracture brittle materials.

Also, since the thermal pulse arrives at a target shortly before the blast, there can be a synergistic effect. That is, thermal radiation can cause significant temperature rises in poor thermal conducting materials such as plastics, fiberglass, and thin skinned metal enclosures which tends to structurally weaken these materials so that they become more vulnerable to blast effects.

3.4 Materiel Response to Air-Blast

Typically, when an object is struck by a blast wave, pressure on the side of the object facing the detonation point is increased above the incident value by reflection, and a local loading of short duration is delivered. This initial loading delivers a hammer-like blow that can cause shock and vibration which can be quite damaging to electronic or mechanical components located inside the enclosure. The reflected pressure pulse can also be the primary damage mechanism for structural items such as panels, walls, and frames. These elements are typically vulnerable to such short duration loading because of the high natural frequencies of these types of structures. As the blast wave continues to engulf box-like objects, lee and internal surfaces may yet be at ambient atmospheric pressure. This can result in differential pressures that tend to crush or deform panels that are not facing the blast (lee side).

Dynamic pressure impulse (high velocity wind during the positive phase) is also an important part of the blast, especially in large explosions like those produced by nuclear weapons. The wind continues to deliver drag loads to an object for a period of time after shock front engulfment. Duration of the drag loading is dependent upon the size (yield) of the weapon. Individual components as well as the whole object that are started in motion during the diffraction phase can be further translated during the drag phase. The end result of this action can be ripping and tearing of structural components, and overturning of large objects such as trucks, enclosures, and trailers. Small pieces of equipment can experience tumbling that cause damage as the equipment impacts solid objects such as trees.

SECTION 4. HARDENING TECHNIQUES

4.1 Hardening to Initial Nuclear Radiation (INR)

4.1.1 Introduction

Hardening to INR, which concerns electronics, should be initiated in the initial design of the equipment to achieve the greatest amount of cost effectiveness. The primary reason for this is that the designer should consider those selective pieceparts and components which are inherently hard to the effects from INR. In addition to the appropriate selection of components, the circuit designer can use current limiting elements to protect components from current surges that can cause burnout. Changing components selection or circuit design late in the development of the equipment can be very costly.

4.1.2 Hardening to Gamma Rays

Total gamma dose hardening can in many cases be obtained by substituting a harder version of vulnerable devices such as microprocessors, RAM's, and related devices. The replacement of soft components may not require a large cost in time or money.

4.1.3 Hardening to Neutrons

Hardening equipment to neutrons consist of selecting inherently hard electronic components.

4.2 Hardening to Electromagnetic Pulse (EMP)

There are two basic approaches which may be followed to harden a system against the effects of EMP. One is to reduce the EMP-induced stress incident at the system, the other is to raise the threshold level at which system malfunction occurs. Stress reduction is accomplished by constructing a closed EMP barrier composed of protection elements; thus creating a protected zone within the barrier. Every protection element of the barrier must provide the specified level of protection for the barrier to be effective, since it will be no better than the weakest protection element. Barriers can be used singly, or they can be nested or layered to create zones of higher protection within other protected zones. A complete closed barrier will almost always include three things:

(1) A shield of sufficient conductivity (especially at seams) to attenuate EMP fields,

(2) Treatment of all shelf apertures so that they are closed to EMP, and

(3) Reducing the number of conductive penetrations to a minimum, and treatment of essential penetrations with transient suppressors.

Placement of electromagnetic barriers has been shown to be an effective means of providing broadband electromagnetic interference control, including HEMP protection. This and other techniques are not limited to ground-based facilities, but can be applied equally well to airborne systems, ships, and spacecraft, sometimes with minor modifications. In general, interference control problems include a source, a sensitive circuit or device, and the intervening space and structure. Placement of an electromagnetic barrier around the source and/or the circuit, controls interference by reducing the source and reducing the sensitivity of the circuit. A complete barrier is a closed surface that prevents both space waves and guided waves (conducted interference) from passing through it. The barrier usually consists of three elements: (1) a metal shield, (2) treatments for penetrating conductors such as filters or other devices, and (3) treatments for apertures, such as screens or conductive coatings over windows and vents.

Increasing thresholds may be used with or in place of stress reduction in EMP hardening. Basic techniques include component substitution, circuit redesign, or functional reconfiguration. The preferred technique will depend on whether the system is to be protected only against damage or against upset as well.

4.3 Hardening to Thermal Radiation

Techniques for hardening equipment to the thermal environment are relatively simple and consist of the following:

1. Appropriate material selection.

   a. Use thermally incentive materials for exposed surfaces.

   b. Use appropriate color selection to increase heat reflectivity.

2. Protective measures.

   a. Use ablatives and similar coatings to dissipate heat.

   b. Use reflective coatings on exposed surfaces.

   c. Use protective shielding over exposed components.

3. Isolation of sensitive components.

   a. Configuration design.

   b. Insulation.

   c. Shutters and other line-of-sight protection.

One method of providing thermal protection is through the use of coatings. Although no data has been found regarding the thermal protection of steel with coatings, there are data for other materials. The most extensive studies were done with commercially available protective coatings on 0.063 in. thick aluminum. Application of these coatings (in the thickness recommended) to the 0.5 in. diameter steel tubing would be expected to result in a peak temperature rise of about 250°C. That would be acceptable since structural steel retains 75 percent of its room temperature strength if its temperature rise does not exceed 415°C.

Based on tests of electrical and fiber optic cable, it appears that polyvinyl chloride, non-flammable polyurethene, or rubber tubing could also be used to protect the steel tubing. However, tests would have to be conducted to determine the appropriate thickness for adequate protection by these materials.

4.4 Hardening to Air-Blast

One approach for hardening equipment to the air-blast environment is to provide sufficient strength that the target can literally stand up to the high pressure loading. However, the design and fabrication of sufficient structural ruggedness has been difficult to accomplish when dealing with high mobility Army equipment. An example of this approach is the development of shelters for Army electronic equipment which has been successful to some degree, but problems exist with regard to cost and weight. The most successful application of this approach is the heavy armored vehicles which are inherently hard to air-blast.

A second approach is to provide air-blast hardening only for those components which are critical to the function of the equipment. This is based on the concept that following a nuclear encounter, only a minimum functional capability of the equipment is required to accomplish the mission. That is, all cosmetic damage is acceptable along with equipment functions which do not contribute to the acceptable minimum performance. An example of an application of this approach is recent work performed on the air-blast hardening of power generator sets. These sets require noise suppression panel enclosures which also provide protection from detection by its thermal signature. Since following a nuclear encounter, noise suppression and thermal signature detection are not important, no attempt is made to prevent these panels from being damaged. However, to protect critical components, it has been proposed that high strength (but small) shields be used and that specially designed standoffs be placed behind the panels (but in front of the critical components). In some cases critical components cannot be adequately protected from air-blast damage, thus a solution may be to simply provide for spare components.

For hardened shelters designed to protect electronic equipment, a specific problem with regard to shock and vibration effects on the electronics exists. That is, when the air-blast impacts the shelter, shocks and vibrations propagate through the walls of the shelter which can cause damage to the electronics. For that reason, special shock isolation techniques are needed to protect the electronics. In addition to shock isolation, space between the shelter walls and the electronic equipment racks can be provided to prevent the deflecting walls from impacting the racks.

In the case where Army equipment can be overturned in the air-blast drag environment and where such overturning cannot be acceptable, the solution usually proposed is to provide for some technique that prevents overturning. Methods to include providing for tie-downs or tethers (which may be feasible if mobility is not a serious consideration). While others involve mounting outriggers (vehicles, trailers, etc) which can be deployed while the equipment is in a stationary mode. If overturn can be tolerated but the equipment needs to be protected from the effects of impacting the ground, then roll bars may be acceptable.

SECTION 5. TESTING AND VALIDATION

5.1 Initial Nuclear Radiation (INR) Testing and Validation

5.1.1 General Issues

INR testing/validation includes testing for permanent damage caused by neutron fluence and total ionizing gamma ray dose as well as transient and permanent damage caused by ionizing gamma ray dose rate. There are general principles which are applicable to all INR tests. First, at a minimum, the test should be designed so that the radiation is delivered to the equipment surface located the furthest from the radiation source. The main reason for this guideline is the shot-to-shot variation of the simulator and the inherent inaccuracies in techniques used to determine dose and fluence levels at a specific location on the target. Due to equipment material shielding and free field intensity variations a distance from the source, an internal piece part may be exposed to a different level than planned. However, by applying the test procedure above, all of the piece parts should be subjected to at least the planned exposure level. To assist in test planning, radiation transport shielding calculations can be performed to approximate the radiation levels to which various internal components will be exposed in a test.

Reactors, flash x-ray machines, and Cobalt 60 sources are typical INR threat environment simulators. The reactor generates both neutrons and gamma rays simultaneously, thus, when the desire is to reduce the magnitude of the gamma ray pulse, the neutron/gamma ray ratio can be increased by using appropriate shielding procedures. In addition, the effect of gamma rays can be reduced by not powering up the system being tested.

The order of various radiation tests are important when only one test specimen is available. Generally it is most effective to perform the test which is least likely to cause a permanent failure in the system. For example, with adequate current limiting devices installed, the gamma dose rate test is least likely to cause a permanent failure, thus that test should be done first. The follow-on test depends on whether the system contains MOS/large-scale integrated (MOS/LSI) circuits and/or recessed oxide bipolar circuits such as certain advanced Schottky integrated circuits. If so, then the neutron fluence test should be performed second since these piece parts are most susceptible to damage from the total gamma dose. Another consideration is the level of residual gamma radiation of the system's material cause by a neutron fluence exposure. If that level is predicted to be too high for post-test operations, then it might be better to perform the total gamma dose test first.

An excellent guide to simulation facilities can be found in DASIAC-SR-89-6 "Guide To Nuclear Weapons Effects Simulation Facilities and Techniques" prepared by K. E. Gould of Kaman Sciences Corporation-Tempo Division for the Defense Nuclear Agency (DNA).

5.1.2 Gamma Dose Testing

Gamma dose simulation and testing is complicated by the time dependence of the radiation response which occurs in semiconductor device materials and the oxide layers. The oxide charge, interface-state buildup, and annealing are affected by the dose rate, the irradiation time, and the time lapse between irradiation and measurement. Experiments have shown that data obtained without accounting for these factors can lead to erroneous hardness assessments. In addition, the gamma dose should be delivered in a time comparable to the time it would take to accumulate the dose in a weapon environment. If the gamma dose delivery time is considerably shorter than the weapon delivery time, the testing damage to most integrated circuits will not be as severe as that which would occur in the actual weapon environment. Cobalt-60 sources are good gamma dose simulators as they produce a dose rate in the range from 50 to 200 rad(Si)/s. Reactors also provide an ample source of gamma radiation, accompanied by neutrons, as long as the reactor is operated in steady state mode. However, reactors are not acceptable facilities for the gamma dosing of electronic equipment. The reactor neutron-to-gamma ratio requires appropriate tailoring, by shielding, to achieve the desired environment. A disadvantage of using a reactor is the difficulty of separating failures caused by neutrons from those caused by the gamma dose.

The test specimen must be operating during a gamma dose test because the response of the piece-parts is a strong function of the bias on them during and after irradiation. Test points should be monitored during irradiation, and the irradiation should be continuous up to failure or until the specimen has been subjected to the specified dose; step-stress exposures are not acceptable because of post-irradiation effects (annealing and additional damage buildup). Post-irradiation effects are unpredictable; therefore an assessment of the system some time following irradiation is meaningless. Even though an out-of-service period is allowed, such an assessment is of no value because of the large variations in the results.

5.1.3 Gamma Dose Rate Testing

Dose rate tests should be performed at the system level because of the complexity and interaction of transient responses. Providing a worst case dose rate test would require that the equipment be tested at its highest operating temperature since latchup is more likely at higher temperatures. Proper circuit/system response in testing is ensured only if the peak prompt gamma dose rate is sustained for a time representative of (not necessarily equal to) the prompt gamma pulse from a weapon.

The Army specifies a maximum pulse width for the ionizing dose rate pulse. The optimum dose-rate simulator should deliver such a pulse with a uniform dose rate (within $\pm$ 20%) to all portions of the test specimen. The best sources for dose rate tests are the large flash x-ray machines. Flash x-ray machines generate considerable amounts of extraneous electrical noise; cables, and possibly associated equipment, need to be shielded. Differential measuring circuitry may be needed to detect real-time signals. It is also necessary to differentiate real experimental effects from problems caused by pickup. This can be accomplished by a pretest shot with the equipment to be tested in place and powered, all monitoring electronics on, but with the beam not delivered to the test cell. Any signals detected should be considerably lower than the expected signals or else the setup may need some correction or modification (e.g., additional lead shielding of cables).

The Aurora flash x-ray machine (located at HDL) approaches the desired output requirements having a pulse width of 125 ns and providing the most uniform illumination across large volumes. In addition, the Aurora facility has a very large exposure room. The Hermes-II and REBA flash x-ray machines (located at Sandia Labs and White Sands Missile Range, respectively) are the next most useful, in that order. They have pulse widths of 50 and 70 ns, respectively. Their axial intensity profile falls off faster than that of the Aurora and their radial distribution is not as uniform, hence, they are less useful for large systems. Any other similar machine should be judged by these same criteria.

The high gamma dose rate tests can induce latchup. Sometimes the equipment specifications will allow latchup when an operator is present to reset the equipment. In the field, there may be a time lag of several minutes before the operator takes action as a result of incapacitation, confusion, or lack of suitable trouble indicators on the equipment. A latched up integrated circuit could conceivably burn out in this time period, and needs to be considered in designing the equipment and planning the test. One way to test for that problem would be to leave the power on for several minutes after the irradiation and then run the diagnostic tests.

5.1.4 Neutron Fluence Testing

The best neutron threat simulation is obtained with a fast-burst reactor such as those at TECOM (White Sands, New Mexico, or Aberdeen, Maryland) or Sandia National Laboratory, NM. The irradiations can either be done pulsed or steady state, depending on the fluence to be accumulated and the uniformity desired. The test specimen can either be powered or unpowered, depending on which yields a worse-case situation. Irradiating the equipment powered and monitored gives better assurance of distinguishing radiation-induced failures from non-radiation-induced failures. Specifically, by monitoring equipment performance up to the time of and through the irradiation, one can unambiguously correlate performance degradation with the radiation exposure. Providing a worst-case test in this environment, on equipment containing bipolar semiconductor devices, would require exposure and testing at their lowest operating temperature because transistor gains drop with temperature. When this is impractical, analysis alone must suffice. Neutron fluence in the test specification is in terms of 1 MeV equivalent damage in Si. The method for converting the reactor spectrum into 1 MeV equivalence is provided in the American Society for Testing and Materials (ASTM) Standard E722-80.

A complication that occurs with neutron tests is the radioactivation of the test specimen. The radioactivity level is minimized by the use of a fast-burst reactor because its thermal neutron fluence is low. Calculations must be used to estimate how "hot" the sample will be after irradiation and how long it will take to "cool" down to a level that it can be handled by personnel. The accuracy of such estimates is limited by the available knowledge of impurities and mass of the radioactive elements in the test specimen.

The uniformity of the neutron fluence across the target should also be considered with a desirable goal of less than ± 20% variation. For a large vehicle or signal shelter, insufficient fluence is available in the reactor pulsed mode. For these cases, either the reactor is run in a steady state mode, or several pulses with the reactor and/or equipment positioned differently are required. If sufficient flux is available, the uniformity can be enhanced by placing the equipment further from the reactor. As this discussion indicates, for large systems, meaningful fluence uniformity objectives can only be met by carefully considering the reactor to be used and the facility operating characteristics. Deviations from the recommended uniformity should be made only when there is agreement among the contractor and Government representatives on where the equipment problems exist. The test design should assure that these problem portions of the equipment are fully exposed. The uniformity problem can also be handled by irradiating subassemblies individually and then reassembling for assembly/equipment tests. This approach has the advantage of avoiding the induced radiation problems associated with large masses of test specimens such as vehicle bodies but due to the relative permanence of damage, is only applicable in the case of neutrons. One risk is the introduction of nonradiation-induced failures by extra handling involved of the subsystems.

Neutron degradation affects are not entirely permanent due to annealing processes that occur over a period of days. This annealing is a function of the temperature of the semiconductor devices in the test specimen as warm semiconductors tend to enhance annealing. Post-irradiation testing should be performed within the specified allowed down time of the test specimen. Testing at the subassembly level is acceptable as long as the degradation of the subassemblies can be combined to give an accurate picture of the performance of the entire test specimen. Care must be taken to insure that proper input and output pin loading is maintained where necessary for this testing approach.

5.2 Electromagnetic (EMP) Validation

EMP simulators fall into two categories: (1) bounded wave and radiated wave and (2) direct drive or current injection simulators. These simulators are used to test the direct effects of atmospheric EMP. The effects of SGEMP and IEMP, which resulted from gamma irradiation, are best examined through the use of INR simulators. However, none of the above methods alone provide an acceptable measure of validation. Validation is accomplished only through a combination of analysis and simulation.

5.2.1 Bounded Wave and Radiated Wave Simulators

Bounded wave and radiated wave simulators produce an EMP which propagates through air either within a bounded volume or over an open ground area, respectively. Systems under test are placed within the volume and their response examined. In addition to testing systems, the shielding effectiveness measurements of shelters and equipment cabinets can be made through the use of these types of simulators.

5.2.1.1 Bounded Wave Simulators

Bounded wave simulators discharge a huge amount of electrical energy, typically stored in capacitor banks, through a conductor network. This conductor network (wire screen), localizes the EMP energy into a bounded volume. These simulators can produce vertically and horizontally polarized waves at amplitudes within the sub-threat range, while operating in either pulsed or continuous wave mode. The simulators also vary in size from small box level to large simulators able to illuminate large systems at full threat amplitudes.

The electromagnetic boundary conditions of the wire screens and the small test volume (when compared to radiated wave simulators) prevent acceptable testing of multi-element systems which contain long interconnections. However, since the wire screens do prohibit ground interaction, they do provide a representative characterization of the EMP threat seen by systems in flight.

5.2.1.2 Radiated Wave Simulators

Radiated wave simulators discharge stored electrical energy through an antenna, allowing the illumination of large areas. Since the energy decreases in intensity geometrically, test subjects are positioned according to the expected threat level. These simulators are typically used in the pulse mode although some can generate continuous wave simulations. Radiated wave simulators produce a signal that is more representative of that which would be seen by systems on or near the ground.

5.2.2 Direct Drive or Current Injection Simulators

Direct drive or current injection simulators are used to directly excite the interface electronics of the test subject. This type of simulation generally involves direct coupling of the test equipment to a pulse generator although capacitive and inductive coupling may be used.

Direct drive simulation is often used to test input/output connections, terminal protection devices, and individual elements of a more complex system. In testing the elements of a complex system, direct drive simulation can be used to evaluate small parts of the system while examining the response of various interconnections. However, for final system validation testing, the complete system must be exposed to threat level to examine all interactions among subsystems/elements. Direct drive techniques may also be used to simulate system (particularly spacecraft) response to the x-ray environment. In this scenario, currents with waveforms similar to those predicted by SGEMP theory, are coupled directly to the test subject surface.

5.2.3 General Considerations for Electromagnetic Pulse (EMP) Testing and Validation

Successful validation of system EMP survivability cannot be achieved by a single test. In most cases, several experimental techniques combined with detailed analyses are necessary before making a low-risk assessment of a system's survivability. Pre-test analyses are also important as they can identify and more specifically define the threat environment. This is useful as the necessary types of testing can then be identified and integrated into the system survivability program.

5.2.3.1 Considerations for High Altitude Electromagnetic Pulse (HEMP) Testing and Validation

Most important in HEMP survivability assessment is the consideration of ground interactions. An accurate assessment of a system's susceptibility to EMP coupling can be made only by incorporating ground conductivity and air dielectric constants.

For threat-level HEMP testing, actual responses from the simulation are compared with the pre-test analysis for agreement. When the methods produce like responses, the analytical tools can be considered valid for predicting system response. Drawbacks to threat-level EMP testing include high cost, potential equipment damage, and lack of 100% simulation accuracy although the results do not have to be extrapolated as with sub-threat simulations.

Sub-threat level testing may be performed through the use of repetitive pulse, single pulse, or continuous wave techniques. Continuous wave testing may be used to illuminate a system throughout a band of frequencies ranging from 1.5 to 250 MHz at both vertical and horizontal polarizations. Fourier analysis may then be used to calculate the transient response with further analysis necessary to incorporate air conductivity effects.

5.2.3.2 Considerations for Low Altitude Electromagnetic Pulse (LEMP) Testing and Validation

LEMP simulations are much more difficult to model as the asymmetries are more complex (time varying) than with HEMP and the gamma ray effects are more pronounced. Since there is no defined coupling code that allows for air conductivity or gamma ray effects, the LEMP pre-test analysis involves considering the electric field effect only. Simulations are then performed as discussed above using threat levels or sub-threat levels. NEST suggests that low-level, free-field vertical simulators, or current injection techniques, be used for verification.

5.3 Thermal Radiation Testing and Validation

In many cases, thermal hardening can be validated by worst-case calculation. The model used for the thermal hardening validation analysis must show that internal temperature rise and surface temperature calculations do not exceed specified hardness margins. Thermal simulators may be necessary in cases where an adequate margin does not exist; these simulators consist of three types: (1) solar collectors, (2) electrical resistance heaters, and (3) thermochemical reactors.

5.3.1 Solar Collectors

A typical solar facility uses an array of mirrors to reflect and focus solar energy onto a test object. Because solar energy is so diffuse, a very large facility is required to create sufficient thermal flux over a large enough area to be useful for most military applications. Solar collectors provide a good simulation of the nuclear weapon thermal spectrum. Focusing all the energy onto a single spot can produce a very high flux, but only over a limited area and with the energy dropping off in a Gaussian manner with distance from the peak flux. Spreading the energy more uniformly over a larger area greatly reduces the peak flux.

5.3.2 Electrical Resistance Heaters

In this method of simulation, electrical energy is discharged through an array of heat lamps or other resistance heaters, to quickly heat the array to very high temperatures and irradiate an adjacent target. Very high fluxes can be achieved over small areas by using mirrors to focus the energy. For large targets, the main limitations are in providing enough total energy and in amassing enough heaters per unit area to provide sufficient flux over a large area for a second or two.

5.3.3 Thermochemical Reactions

The thermal radiation simulator (TRS) is the primary example of this type of simulation. In most current operational versions, powdered aluminum is mixed with liquid oxygen and jetted from an array of four upward pointing nozzles. The ignited jets produce a wall of intense flame that can produce high flux and fluence over large target areas. Research is continuing to increase the flame temperature to more closely simulate the nuclear weapon thermal spectrum. TRS units can be combined to irradiate even larger targets. Some units are transportable and hardened for use in conjunction with High Explosive (HE) field tests and installation in shock tubes for combined blast/thermal testing. DNA uses TRS units extensively at the Permanent High Explosive Test Site at White Sands Missile Range.

5.4 Air-Blast Validation

A successful air-blast validation test usually includes both analytical and test simulation techniques. First, analysis should be performed to predict damage mechanisms and worst-case scenarios. With the analytical results available, the best possibility of designing a successful test occurs. A very important part of the test plan is to choose the correct air-blast simulator which can provide an environment nearest to the one desired. This involves consideration of the destructive nature of the air-blast test as only one validation test is usually possible.

Depending upon the type of air-blast simulator needed to represent the anticipated threat, there are five categories from which to choose: (1) large-scale HE field tests, (2) shock tubes, (3) blast chambers, (4) mechanical shock equipment, and (5) contact-explosive techniques. Large-scale HE tests and shock tubes produce a wave capable of propagation through air, water, and earth which then impinges on the test object. Blast chambers simulate blast overpressure only, which can be used for ground shock simulation. Mechanical shock equipment and contact-explosive techniques are used to directly impose shock excitation onto the test subject.

5.4.1 High Explosive (HE) Field Tests

A large-scale HE field test can provide a very realistic simulation. There are basically two types of these field tests, depending on the configuration of the HE charge. Large-scale point charges, in which the HE charge is constructed in as small a space as possible, can produce high levels of air-blast over large areas for testing entire large systems at various ranges, if desired, to establish or validate distance/damage relationships. Also, underground systems can be exposed to combine air-blast and ground shock and, if desired, systems can be left unsecured to topple or tumble in a more realistic manner. Furthermore, with the advent of transportable thermal radiation simulators (TRS), blast and thermal tests can be combined to study synergistic effects.

Most HE field tests are conducted at established test ranges. Few ranges are sufficiently remote to permit point-charge HE simulations in excess of 1-KT nuclear. DNA has successfully executed HE events equivalent to blast from an 8-KT nuclear surface bursts in addition to several 1-KT simulations. The main disadvantages of such large HE tests are that they are infrequent (currently biennially, unless dedicated to a particular system) and in some cases, costly.

The second type of large-scale HE field test is usually dedicated to a particular buried or partially buried system. Usually, a specially configured (distributed) charge is constructed in a cavity over the test object and is covered with earth to confine and shape the air shock wave. Various arrays of explosives can be combined for high fidelity simulations of the combined airblast and ground shock that a surface or buried target would experience from a large-yield nuclear burst.

Although usually referred to as HE field tests, various types of explosive materials and configurations are possible for large-scale tests, including detonable gas balloons, fuel-air explosives, planar arrays, and linear charges.

5.4.2 Shock Tubes

A shock tube is basically a long horizontal tunnel with a compressed air (or other gas) or explosive "driver" at one end that produces a shock wave which propagates down the tunnel to impinge on an object in the test chamber. Some shock tubes include a soil bed for testing objects that are partially or completely below the ground surface. (Vertical shock tubes that are only for simulating ground shock are categorized as blast chambers in this discussion). It is planned to retrofit some existing shock tubes with TRS systems for combined blast/thermal testing, but no

U.S. tubes currently have this capability. Shock tubes have some significant advantages over HE field tests: tests can be more easily scheduled and are repeatable and less costly, and larger yields can be simulated. Shock tubes are, however, limited in the size and number of test objects they can accommodate. The largest operational U.S. facility has a maximum width of 6.1 meters (20 feet), but it cannot accommodate a test object this large without "blockage" effects in which the blast wave flow is distorted.

5.4.3 Blast Chambers

A blast chamber is simply a strong container for simulating blast over-pressures on a test object or the soil over a buried object. The pressures can be created by an explosive or by compressed gas and the release can be controlled to simulate the decay of a passing airblast wave. Blast chambers are suitable for simulating only the overpressure portion of airblast.

5.4.4 Mechanical Shock Equipment

There are a number of mechanical ways to simulate the initial impact of airblast or ground shock; these include drop tests, mechanical shakers, static and dynamic loaders, etc. Depending on its design, a flyer plate can simulate x-ray impulse or other types of shock. A flyer plate, accelerated to a high velocity by electromagnetic means, is impacted against the test object. A one-m^2 target can be loaded with an impulse of up to about 25 ktaps. With gas guns, a material sample is propelled at high velocity against a stationary surface (or a projectile is propelled against a stationary sample of the test material).

5.4.5 Contact Explosives Shock Techniques

Several methods exist to impose shock directly onto a target by distributing explosives on the target surface (or in very close proximity to it). Depending on their design, such techniques can simulate the impulse from x-rays or airblast or ground shock. Such contact-explosives techniques have evolved over time as better methods have been found. A couple of such methods are described in below, there are undoubtedly others.

In the Spray Lead At Target (SPLAT) technique, strands of mild detonating fuse (PETN explosive encased in lead) are arrayed in close proximity to the test object. When the array is detonated, the target is impacted by small particles of lead. This is a relatively inexpensive technique to produce low impulse on large targets. Impulses typically range from approximately 0.2 to 3 ktaps, with a duration of 50 microseconds. Greater impulses can be achieved by using sheet explosives in direct contact with the target, but fidelity is reduced by shock interactions unless the explosive is evenly distributed. A technique using Dilute Explosive Tiles has been developed in which the explosive is very evenly distributed in foam blocks that can be shaped to conform to the target contours or laid on the ground to create ground shock. Another technique uses a light-sensitive liquid explosive that can be sprayed onto a target. The acetone carrier evaporates leaving the explosive residue which can be detonated by a flash of light.

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ACRONYMS

ASTM	American Society of Testing and Materials
CMOS	Complimentary-symmetry metal oxide semiconductor
DNA	Defense Nuclear Agency
EMP	electromagnetic pulse
FET	field effect transistor
HEMP	high altitude electromagnetic pulse
HDL	Harry Diamond Laboratories
HE	high explosive
IEMP	internal electromagnetic pulse
in.	inch
INR	initial nuclear radiation
km	kilometer
KT	kiloton
LEMP	low altitude electromagnetic pulse
LSI	large-scale integrated
MeV	megaelectron volt
MOS	metal oxide semiconductor
NEST	Nuclear Effects Support Team
NMOS	n-channel metal oxide semiconductor
ns	nanosecond
rad	radiation absorbed dose
RAM	random access memory
ROM	read-only memory
SCR	silicon controlled rectifier
SGEMP	system-generated electromagnetic pulse
Si	silicon
SPLAT	Spray Lead At Target
sq.cm	square centimeter
TECOM	Test and Evaluation Command
TNT	trinitrotoluene
TRS	thermal radiation simulator
TTL	transistor-transistor logic
USAMMDA	U. S. Army Medical Materiel Development Activity
USANCA	U. S. Army Nuclear and Chemical Agency

GLOSSARY

air-blast - see glossary of main text

Ampere's law - The scientific law which defines the relationship between electric current and magnetic fields; the line integral around the area defined by a magnetic field is equal to the current.

annealing - The process in which a material becomes less susceptible to damage through heating and subsequent cooling.

blackbody radiation - The term used to describe the theoretical situation in which a body absorbs all of the radiation that strikes it.

burnout - The condition that results when current and/or voltages through/across a component exceed those specified; in the case of burnout, the excess electrical energy is generally dissipated in the form of heat.

Cobalt 60 - Radioactive isotope commonly used as the isotopic source in initial nuclear radiation effects simulators.

Combat Developer (CBTDEV) - see glossary of main text

Compton current - the current attributed to the flow of Compton electrons.

Compton electron - Photons may collide with electrons, this collision may alter the momentum and energy of the photon; more importantly, an electron may be freed in the process. Electrons produced by this mechanism are referred to as Compton electrons.

deposition (source) region - The area defined by the burst point radiating outward, from which the EMP and other forms of radiation emanate.

dielectric - A material inserted between the plates of a capacitor that allows for the application of higher potential differences before electrical breakdown; the higher a material's dielectric constant, the greater the potential that can be placed across it.

dipole - The physical configuration defined by a positive and negative charge of equal magnitude.

dynamic pressure - The stress imposed on an object as the shock front passes by; characterized by high winds. The dynamic pressure produces drag mechanisms which may overturn, tear away exterior components, and can create general displacement.

electromagnetic pulse (EMP) - see glossary of main test

fireball - The extremely hot, incandescent, spherical air and weapon debris mass; formed by the atmospheric absorption of x-rays resulting from a nuclear detonation.

gamma dose rate - see glossary of main text

gamma rays - see glossary of main text

geomagnetic field - The lines of magnetism that surround the earth and are an inherent part of the atmosphere.

high altitude electromagnetic pulse (HEMP) - see glossary of main text.

initial nuclear radiation (INR) - see glossary of main text

initial nuclear weapons effects (NWE) - see glossary of main text

internal electromagnetic pulse (IEMP) - Electromagnetic pulse generated inside of a volume due to an internally-generated current caused by gamma ray interaction with the electrons in the walls of the enclosure and in the air inside of the volume. It includes the effects of not only EM cavity fields (EMP), but also the internal currents, air conductivity, and replacement currents. Although IEMP is generated by the same mechanism as SGEMP, it is different since SGEMP refers to the electric field on the surface of the equipment and IEMP refers to the EMP created across the interior.

latchup - Latch-up is distinguished from circuit upset since in latch-up the circuit is not automatically restored, and the power into the circuit has to be removed for the restoration of the circuit. A latch-up due to an EMP-induced transient can occur when the transients flowing through the circuit cause a relay or switch to latch-up. A latch-up can also occur within the semiconductor. For example, the n-p-n-p or silicon-control-rectifier can be latched into conductance by an EMP-induced transient, and the power into the circuit has to be removed to unlatch.

logic upset - The condition created in digital circuitry when logic states (0 and 1) become unstable; can generally be corrected through reset capability in which all storage locations are cleared completely and the system restarted.

low altitude electromagnetic pulse (LEMP) - see glossary of main text

Materiel Developer (MATDEV) - see glossary of main text

Maxwell's equations - A set of four mathematical equations that describe the elements of electromagnetism, such as: (1) the relationship between charges and electric fields (Gauss's Law of electricity), (2) magnetism (Gauss's law of magnetism), (3) the electrical effect of a changing magnetic field (Faraday's law of induction), and (4) the magnetic effect of a changing electric field or current (Ampere's law).

metal-oxide semiconductor (MOS) - Type of semiconductor characterized by high input impedance and low static power consumption; commonly used in high input impedance amplifier design, analog switches, and analog signal-processing circuits.

neutrons - One of the subatomic particles located in the nucleus of an atom; the neutron has no electrical charge and, as a result, can travel long, uninterrupted distances. Free neutrons may interact with other atoms to produce gamma radiation.

nuclear hardening criteria - see glossary of main text

photoelectrons - Electrons freed by photon collisions, different from Compton electrons in that all of the photon's energy is translated during the collision. Photoelectrons are commonly created by x-ray/matter interaction.

photons - Individual units of electromagnetic radiation; used when describing electromagnetic radiation interactions on an atomic or molecular level.

Schottky integrated circuits - Semiconductor circuits characterized by small components and low power consumption.

shock front - The dense air mass, created by the nuclear fireball expansion, which propagates outward and initially produces overpressure loading on structures in its path.

shockfront overpressure - The above-ambient pressure air that is existent at the front of the shock wave; is damaging as a result of its transient, well-defined nature.

system generated electromagnetic pulse (SGEMP) - see glossary of main text

thermal radiation - see glossary of main text

transmissivity - The property of an optical material which describes its ability to conduct light.

United States Army Medical Materiel Development Activity (USAMMDA) - see glossary of main text

United States Army Nuclear and Chemical Agency (USANCA) - see glossary of main text

APPENDIX E

NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION

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NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION

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SECTION 1. INTRODUCTION

This appendix is intended to present fundamental NBC contamination information analogous to that included in Appendix D relating to initial NWE. This information will be of use to materiel developers and contractors attempting to satisfy the criteria outlined by the Department of Army Approved Quantitative NBC Contamination Survivability Criteria. Army policy states that all mission-essential materiel must be survivable to the recognized NBC contamination threat. In contrast to initial NWE, redundancy and/or resupply are not completely acceptable alternatives for achieving survivability as the redundant items would likely be contaminated with the units they would replace.

SECTION 2. THE NBC CONTAMINATION ENVIRONMENT

The collective NBC contamination environment is composed of the following individual environments:

(1) Nuclear (N) - Residual radiological contamination consisting of fallout, rainout, and neutron-induced gamma activity.

(2) Biological (B) - All general classes of microorganisms and toxins that can be used as biological warfare agents. This includes bacteria, rickettsia, viruses, fungi, and microbial toxins.

(3) Chemical (C) - All known chemical warfare agents. These include blood agents such as AC, nerve agents such as VX, GB, or thickened GD, and blister agents such as HD.

Therefore, NBC contamination can provide a variety of effects from electron circuit malfunction to exterior material degradation over a wide range of situation to include on-target, off-target, and downwind drifts.

2.1 Residual Nuclear Radiation Environment

The residual nuclear radiation (RNR) environment, a persistent effect following nuclear weapon detonation, is produced by one or any combination of three mechanisms: (1) fallout, (2) rainout, or (3) neutron-induced gamma activity. The RNR environment differs from the INR environment mainly in that the residual environment has a much greater range and is less concentrated. The elements of RNR are discussed below.

2.1.1 Fallout

Immediately following a nuclear detonation, a sun-hot fireball is formed which contains the remains of the weapon, uranium or plutonium reactants, and fragments of the carrier vehicle. As the fireball rises, huge quantities of air are drawn into the trailing cavity. For surface, near-surface, and sub-surface bursts, material on the earth's surface are drawn into the cavity as well and become part of the fireball. The fireball continues to rise while cooling and eventually disappears from sight. The mushroom cloud which then forms continues to carry the radioactive material into the atmosphere and eventually distributes itself over the earth as fallout.

Distribution of the fallout is heavily dependent on the size of the particles. Larger sized particles, visible to the naked eye, fall within a short time while the balance (sometimes microscopic) is distributed by wind. The smaller particles may remain aloft for a significant period of time dispersing over a large air volume. Also, particles which remain airborne for substantial periods will undergo greater radioactive decay, resulting in a lesser threat than those particles having fallen earlier. Wind and particle size are not the only factors which determine fallout distribution as the earth's topography may play a critical role. Areas such as mountaintops could be subjected to higher concentration fallout than areas with a more level geography.

2.1.2 Rainout

Once radioactive debris begins atmospheric circulation, it may concentrate itself within cloud formations. Rain, snow, or other precipitation which either passes through, or falls directly from, this cloud will carry a high concentration of the radioactive particles. This "rainout" will create a localized radioactive environment of greater strength than that which would have resulted otherwise by standard fallout.

2.1.3 Neutron-Induced Gamma Activity

Among the products released in the chemical reactions which occur during a nuclear detonation are neutrons. As the neutron is a neutral (uncharged) particle, it may travel long distances unaffected by the positive and negative charges of the matter through which it passes. However, if the neutron is absorbed by the nucleus of another atom, that atom may become unstable and radioactive. When this occurs, the material which contains the now radioactive nuclei may emanate gamma radiation.

The DA Approved NBC Contamination Survivability Criteria for Army Materiel outlines a worst case NBC contamination scenario to which equipment must be survivable. These criteria quantify the RNR environment as one in which materiel would be covered with 4 g/m^2 of insoluble radioactive contaminants 37-200 micrometers in size at a radioactive decay level of 185 GBq/m^2. The surface temperature for this environment is specified as 30°C accompanied by a no greater than 1 m/s wind.

2.2 Chemical and Biological Agent Environment

The chemical and biological agent environment is produced through the use of one or any combination of the following delivery/dissemination systems: missiles; artillery; mines; multiple rail and tube-launched rockets; fighter bombers and attack helicopters with aerial bombs, rockets, and spray tanks. Following the introduction of these agents into the environment, they distribute themselves as either a vapor, solid or liquid aerosol, or as less slowly evaporating liquid droplets.

The DA Approved NBC Contamination Survivability Criteria specifies the chemical/biological portion of the NBC contaminated environment as consisting of 10 g/m^2 of each of the following chemical agents: thickened GD, VX, and HD each having a mass median diameter of 2-5 mm and 10^5 spores/m^2 of biological agent 1-5 micrometers in size. Climatic conditions are further defined in this worst case scenario by specification of a 30°C temperature and an exterior wind of no greater than 1 m/s.

2.3 Tactical Considerations

Although the NBC contaminated environment is capable of degrading system performance, the primary tactical interest is in preserving a safe operating environment for personnel. The NBC contamination threat is personnel-directed in that personnel are either incapacitated or forced to adopt protective measures. Upon entry into an NBC contaminated region, personnel are exposed to an inhalation hazard (from the existing vapor or evaporating solids and liquids) and a contact hazard (through bare skin contact with equipment surfaces). As a protective measure, soldiers are provided an ensemble which includes an NBC protective mask, protective clothing, gloves, and boots. Wear of this protective ensemble over time is encumbering, causing loss of tactical abilities, reduced vision, and reduced work capacity. Therefore, the primary emphasis in this situation is the reduction of the hazard to the point where protective measures may be abandoned or relaxed. Since weathering is an unpredictable means of achieving this reduction, active procedures are incorporated to expedite the process.

SECTION 3. DECONTAMINABILITY, HARDNESS, AND COMPATIBILITY

The NBC contamination threat is primarily a personnel threat. Although the contamination environment itself does present unique problems to materiel survivability, the materiel developer is most concerned with the synergistic crew-system relationship. As a result, the materiel development effort must take into consideration not only the threat environment, but also the techniques necessary to reduce the threat to safe levels (decontamination). In addition, special human-factors engineering efforts must be made to accommodate the soldier clothed in the NBC protective ensemble. The multiple facets of the NBC contamination survivability program are outlined in the following discussions.

3.1 Decontaminability

The principal benefit of decontamination is to allow reduction of existing protective measures for the crew. In an effort to create the safest, most efficient operating environment, toxicity levels have been analyzed to determine negligible risk levels. These risk levels must be achieved by the decontamination process. Decontaminability is enhanced by considering the following: maximize the use of materials which do not absorb contaminants and which facilitate their rapid removal with standard decontaminants; incorporate designs that reduce or prevent contaminant accumulation and make exposed areas readily accessible for decontamination; employ devices and means that reduce the contamination amount to be removed (use of positive overpressure systems, packaging, and protective covers); and provide for the integration of NBC detection, measurement, decontamination, and contamination control devices.

3.2 Hardness

Hardening to the NBC contamination environment has two components, hardening to the damaging effects of NBC contamination and subsequent decontamination procedures.

3.3 Compatibility

Compatibility is the ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC-protective ensemble. In some instances, collective protection may substitute for compatibility. Collective protection refers to the use of an enclosure to provide a safe operating environment, through the use of high efficiency particulate filters and positive overpressure systems. If collective protection is chosen as the means for achieving compatibility, there is the risk that the enclosure may be contaminated before protective mechanisms are operating. Compatibility is largely a human factors engineering issue as special considerations must be given to the soldier (in protective clothing)/equipment interface.

3.4 NBC Contamination Survivability : Materiel Effects and Design Considerations

3.4.1 Materiel Response to the NBC Contamination Environment

The first concern of the materiel developer is to ensure that the equipment being produced will be survivable to the NBC contamination environment itself. This involves hardening to chemical/biological agent and RNR exposure.

3.4.1.1 Materiel Response to Residual Nuclear Radiation

Historically, there has been a belief that equipment hardened to INR is hardened to RNR. While this is generally true, there is a concern over equipment that has been designated nuclear survivable by virtue of its redundancy. As this equipment has not been hardened to radiation effects, it is possible that any RNR to which it may be exposed will be strong enough to damage fiber optics, complimentary-symmetry, metal oxide semiconductors (CMOS) circuitry, and digital integrated circuits (ICs).

The Chemical/Biological Information Analysis Center (CBIAC) is currently compiling a database of RNR effects. For materiel to which the above situation is applicable, CRDEC should be consulted to ensure that survivability to RNR is not compromised.

3.4.1.2 Materiel Response to Chemical/Biological Agents

The threat posed by chemical/biological agents has been frequently treated as a singular concern from the materiel development perspective. Biological agents basically pose a similar (often less damaging) threat to equipment as, and the decontamination process is similar to that used for, chemical agents. Therefore, this discussion will be presented in regards to the chemical agent environment only. Any biological agent-specific concerns should be handled through CRDEC and CBIAC.

Chemical agents are powerful organic solvents and will dissolve into many polymeric materials producing blisters and soft spots. However, chemical agent effects on bulk structural plastics should be insignificant with the exception of potential stress crazing (under load) for a few polymers. The greatest threat to polymers is that of surface pitting and crazing with transparent items such as instrument covers, polycarbonate lenses, and windshields.

The hydrolysis of nerve agents will in some cases yield a hydrofluoric acid by-product. Glass and germanium surfaces are vulnerable to etching by this acid if not protected. Acidic impurities may also affect the operation of delicate equipment.

In general, chemical agents are damaging as a result of their solvating powers. This problem is most pronounced when the agents are in liquid droplet form, due to the ease with which the agent may spread. As a vapor, chemical agents may penetrate the interior of the equipment. However, the interior concentration of the agent is, in most cases, reduced (by a factor of 10 relative to the exterior concentration) to the point of insignificance. Only extremely corrosive agents or the use of very delicate electronic components may create a situation in which damage is a concern. AEP-7 "Chemical Defence Factors In The Design of Military Equipment" contains data regarding the permeability and absorption characteristics of common materials to the chemical agents mustard gas (HD) and nerve agent (VX).

3.4.2 Materiel Response to Decontamination

Decontaminants are most often solvent-based liquids which are chemically, very aggressive. Therefore, the materiel developer must be concerned with choosing materials that are resistant to adverse decontaminant, as well as contaminant effects. A Hughes Aircraft study was used as a forum for examining the exposure response of many common materials to the standard decontaminants. Decontaminating Solution No. 2 (DS2 [DS2 consists of 70% diethylenetriamine, 28% methyl cellosolve, and 2% sodium hydroxide]) and Supertropical Bleach (STB [STB consists of a chlorinated lime and calcium oxide mixture containing 30-37% free chlorine]). The results of this study are contained in the "Army Materials Handbook for NBC Contamination Survivability", Chemical Research, Development, and Engineering Center. The results of this study are briefly summarized below:

Test items were immersed in DS2 and STB for both two hours and for 24 hours. This test procedure allowed for examination of simulated field conditions as two hours may approximate the total decontamination time necessary for encounters on the integrated battlefield. The 24-hour window allowed for the identification of materials that would degrade following repeated exposures. The following categories of materials were tested: elastomers, plastic coatings, and metals.

Elastomers: DS2 was found to significantly harm elastomers more so than STB. The organic solvent amine and the sodium hydroxide components of DS2 were found to cause major damage to nitrile, flourosilicone, polysulfide sealant, and flourosilicone DC 730 sealant. STB-related degradation was primarily limited to the discoloration of rubber.

Plastics: 24-hour exposures of plastics to DS2 and STB revealed no problems with the exception of two instances. DS2 was found to dissolve polycarbonate and, following only a short exposure to DS2, the polycarbonate was found to show severe crazing and subsequent failure while under stress. Nomex 414 undergoes severe degradation following DS2 exposure.

Coatings: Three common circuit board coatings and a vehicle undercoating were observed. Acrylic and urethane were severely affected by DS2 to the point of dissolution. However, the third conformal circuit board coating, Parylene, was unaffected by exposure to both DS2 and STB. The vehicle undercoating displayed minor signs of solvent attack after DS2 immersion, but was unaffected by STB.

Metals: STB was found to have a more abusive effect on metals than DS2. The results of the study indicate that DS2 be chosen over STB when decontaminating the following: metal alloy/finish combinations, carbon and low alloy steel/finish combinations, aluminum alloys, copper alloys, and silver-plated alloys/sterling silver parts. Chromium-plated carbon and low alloy steels may also be decontaminated with STB. Corrosion Resistant Steels (CRES) may be decontaminated with either DS2 or STB.

An extensive list of decontaminants and their chemical composition is contained in AEP-7. A list such as this, combined with data describing the effects of various chemical agents on construction materials are integral elements in the effort to design NBC contamination survivable equipment. This type of information and other related NBC contamination data have been compiled by the CBIAC and are now located in various CBIAC-administered automated databases.

3.4.3 Contamination, Decontamination, and Design

Minimization of contamination and facilitation of decontamination are best achieved through design measures. Fortunately, these are complimentary goals from the designer's perspective. In general, designs which minimize contaminant penetration and promote runoff will also aid in the effectiveness of decontamination procedures. Equipment exteriors are the primary concern in designing NBC contamination survivable equipment. Exteriors which resist the entrapment, retainment, and penetration of agents are well-equipped to withstand NBC contamination.

Equipment that requires the incorporation of canvas, elastomers, and paints frequently are configured such that agent absorption occur a hazardous degree. To minimize this, canvas components should be designed for easy removal with minimum handling, elastomers shielded or incorporated to be easily removed, and surfaces should be painted with chemical agent resistant coating (CARC). CARC may also be used as a sealant for crevices/capillaries that may hold agents.

Sealing is an important mechanism in designing for NBC contamination survivability as the junction of two items often produces small openings into which agents may be absorbed. Examples of this include a lapped interface (joining of sheet metal, cabinet walls and doors, compartment covers, and deck plating), permanent fasteners (rivets which may loosen following vibration), removable fasteners, exposed screw threads, knobs, switches, displays, connectors, and handles. As mentioned earlier, CARC may be used as a sealant; however, welding may also be used in many instances. In the case of knobs, switches, displays, and connectors, design techniques, as opposed to the application of physical sealants. may provide the solution. For example, the use of cowling and/or recessed instrument panels with hoods and transparent covers provide an alternative for these hard-to-seal areas. The use of plastic fairings can serve as a protective cover for complex surface geometries. Other techniques include the use of internal hinges for exterior doors, welded exterior handles, butyl rubber sleeving over exposed springs, and directly-stamped nameplates as opposed to rivet-fastened, sheet metal nameplates.

In the final analysis, designs must be weighed against functional requirements to ensure that operational effectiveness has not been compromised. Guidelines for designing NBC contamination survivable equipment may be obtained through consultation with CRDEC/CBIAC and through existing publications such as: AEP-7 and the CRDEC handbook: "Guidelines-Design to Minimize Contamination and to Facilitate Decontamination of Military Vehicles and Other Equipment: Interiors and Exteriors."

3.4.4 Compatibility and Design

Compatibility is solely a function of equipment design. Soldiers in the protective ensemble must be able to operate equipment with a minimum loss of efficiency. With this being the case, equipment must be designed with the following considerations: sharp edges and corners that would damage the protective clothing must be avoided; buttons, switches, rotary controls, and handles must be accessible by protective gloved-hands with no significant possibility of incorrect operation; and optical devices, gauges, and displays must be designed to compensate for limited peripheral vision and focusing differential through the protective mask.

As with designing to satisfy other NBC contamination survivability criteria, CRDEC/CBIAC maintains an extensive library of material designed to aid materiel developers. AEP-7 also contains several quantified design parameters to aid in satisfying the compatibility criterion.

SECTION 4 - TESTING AND VALIDATION

4.1 General

All mission-essential materiel must be tested and validated to verify the specifications outlined by the DA Approved NBC Contamination Survivability Criteria for Army Materiel. Verification of decontaminability and hardness is best done through Technical Testing (TT). The compatibility issue, although it should also be examined during TT, is most effectively addressed through User Testing (UT). The following decontaminability, hardness, and compatibility criteria need to be addressed before a system survivability be considered validated.

4.1.1 Decontaminability Criteria

The equipment is contaminated with each of the NBC components under worst case environmental conditions (see the DA Approved NBC Contamination Survivability Criteria for Army Materiel). Under a typical decontamination scenario (time allowed after contamination before decontamination begins, time allowed for decontamination) negligible risk values are specified. These values (see the DA Approved NBC Contamination Survivability Criteria for Army Materiel), constitute levels of contamination which present negligible risk to personnel working inside, on, or 1 meter from the item.

4.1.2 Hardness Criteria

Materiel shall suffer no more than 20 percent degradation, in selected quantifiable mission essential performance characteristics, following a 30-day period involving 5 complete exposures to NBC contaminants, decontaminants, and decontaminating procedures. The 20 percent value many be changed, providing the combat developer can present approved rationale.

4.1.3 Compatibility Criteria

Mission-essential functions must be performed by trained and acclimatized troops over a typical mission profile. These functions (operations, communications, maintenance, resupply, and decontamination) must be performed in a contaminated environment, for no longer than 12 hours under all expected meteorological conditions. A degradation of 15 percent in selected quantifiable characteristics, is allowed (excluding heat stress) for comparison with operation in a non-NBC environment. Again, the 15 percent figure is flexible depending on combat developer needs and rationale.

4.2 NBC Contamination Survivability Testing and Special Considerations

Testing to ensure that these criteria have been met is considered to be destructive-type testing. This creates a problem when working with a limited number of prototypes thereby establishing the foundation for performing trade-off analyses. A well-structured test and validation program will include trade-off analyses that are aimed at evaluating critical components and materials. CRDEC has established databases to aid in these trade-off studies and evaluations which may eliminate the need for full-scale testing. However, when testing is a necessity, the U. S. Army Test and Evaluation Command (TECOM) has prepared several TOPs which outline specific types of NBC contamination survivability testing. These protocols include TOP 8-2-510 (testing for large, externally-contaminated items such as vehicles, shelters, and packaged materials) and TOP 8-2-11 for small items.

The hazards inherent to NBC contamination necessitate that specific requirements be satisfied prior to undergoing survivability testing. Included among these requirements are those for test facilities and qualified personnel, compliance with provisions of the National Environmental Protection Act (NEPA), and adherence to AR 50-60 and AR 50-60-1 (which outline Army policies on chemical surety).

4.2.1 Test Facilities and Personnel

Test facilities must be constructed to enable safe storage, handling, testing, decontamination, and containment of hazardous materials. Buildings used for testing must be constructed such that all exhaust air be filtered and all waste be disposed to prevent agent release into the environment. A laboratory must also be included which is equipped to safely store, prepare, and analyze samples.

Finally, it is also essential that test personnel have access to a shower facility where protective clothing changes can be made and showers taken following contact with agents.

Test instrumentation should include samplers for hazardous vapors, a vapor sampling basket, contamination density samplers (Printflex cards, filter paper, etc.), chemical analysis equipment (spectrophotometer, chromatograph, etc.), counting and sizing equipment or image analyzers, contact hazard samplers, agent applicating equipment, agent alarms and monitors, decontaminating utilities, packaging for in-test transport, gas-tight waste collection containers, standard climate monitoring devices (thermometer, hygrometer, and wind-speed measuring instrument), biological simulant spray devices, calcium alginate bacteriological swabs, test tubes, diluent, and photographic equipment.

Trained personnel are also required to contaminate samples, analyze, decontaminate, measure post-test contaminant levels, and to store, handle and monitor toxic materials.

4.2.2 Environmental Assessments

Environmental assessments are required by the NEPA for all test installations. This assessment includes evaluation of storage and disposal capabilities. If TECOM facilities such as Dugway Proving Ground are chosen for testing, proper Categorical Exclusions may be applicable and could satisfy the Environmental Assessment requirement. This would prevent the contractor having to perform an independent environmental assessment.

4.2.3 Simulants

The complexity of using NBC agents requires the use of surety facilities and may also present a substantial demand on program resources (preparation time, personnel training time, cost, and material availability). In cases where resource limitations are not an issue, regulatory constraints may complicate testing with the use of live agents. (The NEPA of 1969 requires Congressional notification prior to the conduct of open-air testing). These factors have made simulant testing a popular alternative.

Although simulant agent testing does allow for safer, less expensive, and more timely testing, this practice also carries certain limitations. The greatest concern associated with simulant testing is that the simulants cannot perfectly parallel the behavior of the actual agents. This creates uncertainty concerning the reliability of the test data which must be minimized. Choosing a suitable simulant for NBC contamination survivability testing requires an evaluation and comparison of simulant vs. agent properties such as persistence, wettability, sorption, and general reactivity. This analysis requires not only attempting to match the chemical and physical properties of the agent and simulant, but examining potential degrading interactions that may occur with the simulant but not with the agent itself.

Solubility or sorption is an important parameter since it determines the degree to which an agent or simulant may penetrate a given substrate. It is generally the case that the greater the resemblance between the penetrant and substrate, the higher the sorption. In choosing simulants that closely emulate an agent's solubility, the respective molecular dimensions should be examined, and in most cases, matched as closely as possible. Wettability is important as it determines the ability of an agent to adhere to a given surface and therefore, also determines the ease with which it can be removed through decontamination. The important parameters to evaluate, when examining simulant vs. agent wettability, are contact angle and surface tension. The contact angle is important because it is a measure of a drop's tendency to spread across a surface and helps define the bond strength. The surface tension threshold indicates the point at which liquids cease to bead and will flow spontaneously across a surface. Chemical reactivity is considered less critical than matching solubility or wettability. Differences in agents/simulant chemical reactivity are more easily mathematically corrected than are differences in the other parameters. However, the persistence (evaporation) of both agent and simulant should be monitored closely.

Although solubility, wettability, and chemical reactivity are the most important parameters to evaluate when attempting to match a simulant to an agent, there are other factors to consider. Among these are: the thickness of the contaminated layer formed by a spreading drop, thickener solubility, reaction rate of decontaminant and simulant, and the extent of decontamination reaction and position of final equilibrium. As with many other issues associated with NBC contamination survivability, CRDEC/CBIAC has established databases to aid in the choice of appropriate simulants for testing.

4.3 Test Preparation

The following protocol for preparing an NBC contamination survivability test has been extracted from TOP 8-2-510 and will aid in: minimizing unnecessary testing, promoting efficient testing, and facilitating analysis.

The primary emphasis in NBC survivability testing must be placed on test safety when working with hazardous materials and on the quality and completeness of all test data.

- Identify potential problem areas by reviewing previous test procedures and records and the results of testing of similar items and procedures. Consult applicable safety and surety regulations for test procedure compliance. Review standard operating procedures to be used for applicability, completeness, and adequacy.

- Identify the mission profile for the test item and the performance characteristics that will be used in measuring the NBC contamination survivability. Integrate them with the DA Approved Quantitative NBC Contamination Survivability Criteria for Army Materiel including the requirements for decontaminability, hardness, and compatibility.

- Examine the test item design principles and materials of construction. Compare them with handbook material lists and make a subjective judgement based on previous test experience and professionalism concerning their ability to survive contamination, decontaminants, and decontamination procedures. Ensure that any questionable design or material used is adequately tested. Any questionable design or material so identified may be a candidate for preliminary "swatch" testing in the laboratory.

- Select and identify areas of the test item to be contaminated, decontaminated, and sampled for residual contamination. Ensure that the areas selected are typical and representative of the total test surface, materials of construction, and areas likely to be contaminated in an NBC environment.

- Identify specific decontaminants, decontamination procedures, sampling, sample analysis procedures, and support equipment to be used.

REFERENCES

(1) Nuclear, Biological, and Chemical (NBC) Contamination Survivability: A Handbook For Development/Management of Materiel Programs, September 1985, Chemical Research, Development, and Engineering Center, U.S. Army Armament, Munitions, and Chemical Command, Aberdeen Proving Ground, MD 21010-5423.

(2) Army Materials Handbook for NBC Contamination Survivability, Chemical Research, Development, and Engineering Center, U.S. Army Armament, Munitions, and Chemical Command, January 1983, Aberdeen Proving Ground, MD 21010-5423.

(3) Allied Engineering Publication 7, Edition 2, Chemical Defence Factors in the Design of Military Equipment, May 1988.

(4) Department of the Army Approved Quantitative NBC Contamination Survivability Criteria for Army Materiel, 1 February 1989, U.S. Army Nuclear and Chemical Agency, 7500 Backlick Road, Springfield, VA 22150-3198.

(5) Feeney, Dr. Joseph J., "A Program Manager's Guide to Producing Survivable Systems", Program Manager, March-April 1989.

(6) Chemical Warfare/Chemical Biological Defense Information Analysis Center Newsletter, Summer 1986, Battelle Edgewood Operations, 2113 Emmorton Park Road, Edgewood, MD 21040

(7) Smith, Robert C., How To Survive A Nuclear Disaster, New York, NY, Kensington Publishing Corp., 1982.

(8) Katz, Arthur M., Life After Nuclear War, Cambridge, MA, Ballinger Publishing Company, 1982.

(9) Goodwin, Peter, Nuclear War: The Facts On Our Survival, New York, NY, The Rutledge Press, 1981.

ACRONYMS

AR	Army Regulation
CARC	Chemical Agent Resistant Coating
CBIAC	Chemical/Biological Information Analysis Center
CMOS	Complimentary-symmetry metal oxide semiconductor
CRDEC	Chemical Research, Development, and Engineering Center
CRES	Corrosion Resistant Steel
DS2	Decontaminating Solution No. 2
g/m^2	grams per square meter
GB	Isopropyl methylphosphonoflouridate
GBq/n^2	giga Becquerels per square meter
GD	Binocolyl
HD	2,2' - Dichlorodiethyl sulfide
IC	integrated circuit
m/s	meters per second
mm	millimeter
NBC	nuclear, biological, chemical
NEPA	National Environmental Protection Act
NWE	nuclear weapons effects
RNR	residual nuclear radiation
STB	Supertropical Bleach
TECOM	Test and Evaluation Command
TOP	Test Operations Procedure
TT	Technical Testing
USAMMDA	U. S. Army Medical Materiel Development Activity
UT	User Testing
VX	O-ethyl S-(2-diisopropylaminoethyl) methylphosphonoflouridate

GLOSSARY

biological agent - see glossary of main text

chemical agent - see glossary of main text

Chemical/Biological Information Analysis Center (CBIAC) - A Department of Defense Information Analysis Center which collects, evaluates, and disseminates Chemical Warfare/Chemical-Biological Defense-related information. The CBIAC offers the following services: review and assessment of pertinent technologies, establishment and operation of several databases; preparation of state-of-the-art reports and handbooks; and other services ranging from small-scale problem solving to technical consultation.

chemical reactivity - see glossary of main text

Chemical Research, Development, and Engineering Center (CRDEC) - see glossary of main text

collective protection equipment (CPE) - see glossary of main text

compatibility - see glossary of main text

conformal coating - A coating designed to protect circuit boards and the attached components from environmental effects.

decontaminability - see glossary of main text

Decontaminating Solution No. 2 (DS2) - A 70% diethylenetriamine, 28% methyl cellosolve, and 2% sodium hydroxide solution provided for use as a decontaminating agent; effective against all known toxic chemical agents and biological materials except spores.

Environmental Assessment - Documentation, required by the National Environmental Protection Act of 1969, that fully addresses the environmental impacts of any action involving the use of hazardous materiels.

fallout - see glossary of main text

gamma rays - see glossary of main text

ground zero - The location (on the ground) that is either the actual point of, or is directly beneath the point of, a nuclear detonation.

hardening - see glossary of main text

high efficiency particulate filter - A filter used in conjunction with positive overpressure systems through which continually circulating air is introduced into the enclosure. The filter is capable of filtering out particulates as small as 0.3 micrometers at an efficiency rate of 99.7 percent.

neutron-induced gamma activity - see glossary of main text

positive overpressure system - A system employed with enclosures (tents, shelters, etc.) in which the pressure within the shelter is kept at a greater level than the outside ambient air pressure. This outward-exerting pressure acts as a pneumatic sealant, preventing the entry of outside contaminants.

rainout - see glossary of main text

residual nuclear radiation (RNR) - see glossary of main text

solubility - see glossary of main text

Supertropical Bleach (STB) - A chlorinated lime and calcium oxide mixture containing 30-37% free chlorine used as a decontaminating agent; effective against lewisite, V agents, G agents, and biological agents; ignites when contacts DS2 or blister agent; and releases toxic vapors upon contact with G agent.

technical testing (TT) - see glossary of main text

Test and Evaluation Command, U. S. Army (TECOM) - see glossary of main text

U. S. Army Medical Materiel Development Activity (USAMMDA) - see glossary of main text

user testing - see glossary of main text

wettability - see glossary of main text

APPENDIX F

NUCLEAR AND NBC CONTAMINATION SURVIVABILITY DATA ITEM DESCRIPTIONS

APPENDIX F

DATA ITEM DESCRIPTIONS

This appendix presents a version of the Data Item Descriptions (DIDs) which make up an important part of the Request for Proposals (RFPs). DIDs relating to both nuclear and NBC contamination survivability are included, but for information purposes only. The Nuclear Effects Support Team (NEST) and the Chemical Research, Development, and Engineering Center (CRDEC) should be contacted to obtain the actual inputs.

SECTION 1. - NUCLEAR SURVIVABILITY DATA ITEM DESCRIPTIONS

SECTION 2. - NBC CONTAMINATION SURVIVABILITY DATA ITEM DESCRIPTIONS

SECTION 1. NUCLEAR SURVIVABILITY DATA ITEM DESCRIPTIONS (DIDs)

DATA ITEM DESCRIPTION # DI-NUOR-80156

1. TITLE: NUCLEAR SURVIVABILITY PROGRAM PLAN

2. IDENTIFICATION NUMBER: DI-NUOR-80156

3. DESCRIPTION /PURPOSE:

   3.1 The Nuclear Survivability Program Plan describes how the contractor's Nuclear Survivability Program will be conducted. It describes design, analyses, tests, and management activities to be performed to satisfy the nuclear survivability criteria of air-blast, thermal radiation, nuclear radiation, and electromagnetic pulse.

   3.2 This plan provides the basis for the Government's determination that the contractor's Nuclear Survivability Program will meet contractual requirements in a cost-effective manner and is applicable to development and non-development programs.

4. APPROVAL DATE:

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR): SLCHD-NW-P

6A. DTIC REQUIRED:

6B. GIDEP REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for nuclear survivability in the Proof-of-Principle or the Development-Production Prove-Out acquisition phase, this Data Item Description (DID) shall be listed on the Contract Data Requirements List (CDRL) using DD Form 1423 with delivery required 60 days after contract award.

   7.2 Alternate application. Nuclear Weapons Effects (NWE) on Army Tactical Systems, Vol. II, Management, HDL-TR-1882-II, explains how this DID can be made a requirement of a bidder's response to a solicitation and the benefits derived from this alternative approach.

   7.3 NWE on Army Tactical Systems, Vol. I, Overview, HDL-TR-1882-I, provides the philosophy and guidance for design, analysis, and evaluation of Army systems' nuclear survivability in supporting the DID preparation.

   7.4 AR 70-60, Nuclear Survivability of Army Materiel, contains the Army policy applicable to nuclear survivability. HDL-CR-81-015-1, HDL-SR-85-3, DNA 1420-H (1 and 2), DNA 2114-H (1 through 4), DNA 3286-H, and DASA 2432-H are reference documents that provide background information.

   7.5 All identified documents, except AR 70-60, are available from the Defense Technical Information Center.

   7.6 This DID supersedes DI-R-1758A.

8. APPROVAL LIMITATION:

9A. APPLICABLE FORMS:

9B. MSC NUMBER: A3819

10. PREPARATION INSTRUCTIONS:

10.1 Reference Documents. The applicable issue of the documents cited herein, including their approval dates and dates of any applicable amendments, notices and revisions, shall be as reflected in the contract.

10.2 General. The Nuclear Survivability Program Plan shall specify the methods and techniques for incorporating nuclear survivability into design, development and equipment integration, and for conducting a comprehensive nuclear survivability validation program. The program plan shall be prepared consistent with the information contained in HDL-TR-1882-I, HDL-SR-85-3, AND HDL-CR-81-015-1, and shall include the information as described below.

10.3 Specific tasks.

(a) The specific tasks for design, analysis, test, evaluation, and management of the nuclear survivability requirements.

(b) A time and event schedule of initiation, review, and completion for each task.

(c) Parts, materials, facilities, equipments, subsystems, and system requirements for each task.

(d) The estimated labor hours, the caliber of labor and the costs (such as labor, material, supplies, travel, computer, and simulation facilities).

10.4 Designs, analyses, tests, and evaluations.

(a) The delineation of analytical efforts that supplement or replace testing, to include the identification of computer codes, and the ways that these analytical techniques will be used.

(b) Piecepart, component, and subsystem tests to be performed for each specified nuclear environment, with details, such as numbers of samples, test methods, test instrumentation and parameters to be characterized.

(c) System level tests to be performed, including the method of extrapolation from the test environment to the threat environment and the rationale for simulator choice.

(d) Simulators to be employed, test configurations, target orientation, exposure levels, test data to be obtained, and their relationship to analytical efforts. Reference HDL-SR-85-3.

(e) The survivability philosophy to include the basis for selection of pieceparts, materials, device technologies, circuit and mechanical designs; the specific materials, technologies and designs rejected because of nuclear survivability considerations; assumptions concerning the system design margins; planned operational fixes such as cycling power, and any assumption concerning the system operation, function, deployment or configuration that has been used in developing the Nuclear Survivability Plan. There shall be particular emphasis on design philosophy for hardness critical items (HCI) and mission critical equipments. An HCI is a hardware item at any indenture level which is mission critical and could be designed, repaired, substituted, manufactured, installed, or maintained for normal operation and yet degrade system hardness in a nuclear environment if hardness were not considered. (See DoD-STD-100).

(f) The incorporation of nuclear survivability issues and considerations into the appropriate Integrated Logistics Support (ILS) documentation as early as possible in the program. The application of Nuclear Survivability Program results to the production (hardness assurance) and Integrated Logistics Support (hardness maintenance and surveillance) of the system. The Integrated Logistics Support implications shall include maintenance, repair and overhaul procedures, personnel skill levels, spare parts, repair tools, source control, and resupply of parts and training needs.

(g) The projected requirements, driven by the nuclear survivability of the system, for special or custom parts, materials, or components; the basis of need for these parts; and the impacts of these requirements on the program and system design, cost, operation, function, and deployment.

(h) If the prime contractor or any of the subcontractors are supplying proprietary materials, components or equipments under this contract, this plan must detail how the nuclear survivability of these materials, components or equipments will be evaluated, assured, maintained and documented during Proof-of-Principal, Development-Production Prove-Out, and Production and Deployment Phases.

(i) The plan shall identify the nuclear survivability tradeoffs that will be performed against other system requirements such as schedule, cost, mobility, reliability, producibility, and Integrated Logistics Support.

10.5 Risk analysis and identification.

(a) The identification of the nuclear survivability areas of high risk and uncertainty.

(b) The identification of assumptions, conclusions, and reasons used in risk analysis and identification.

(c) The identification of actions to be taken to minimize impact of risk and uncertainties identified.

10.6 Management interface controls.

(a) The interface between the Nuclear Survivability Program and other related programs, such as engineering design, reliability, Integrated Logistics Support, production engineering, and producibility programs.

(b) Methodology and procedures by which the prime contractor will ensure nuclear survivability in subcontracts.

(c) The identification of actions to be taken to ensure nuclear survivability (to include validation, assurance, and maintenance) for materiel to be developed elsewhere, namely, any non-development items.

(d) The identification of special requirements to be included in source or product selection.

(e) The management strategy for items which do not meet system or materiel survivability requirements.

10.7 Program management.

(a) The identification, responsibilities and authorities of the Nuclear Survivability Program Manager and the nuclear weapons effects experts assigned to the program.

(b) Management procedures and controls available to assure the successful application and accomplishment of nuclear survivability requirements.

10.8 Additional information. Additional information necessary to adequately delineate the Nuclear Survivability Program.

DATA ITEM DESCRIPTION # DI-R-1759A

1. TITLE: NUCLEAR WEAPONS EFFECTS TEST PLAN

2. IDENTIFICATION NUMBER: ARMY, # DI-R-1759A

3. DESCRIPTION /PURPOSE:

   3.1 The Nuclear Weapons Effects (NWE) Test Plan prescribes the general procedures, terms, and conditions governing the planning, preparation, implementation, and reporting of NWE testing that will constitute adequate proof, when combined with other data analysis, that ar acceptable level of nuclear survivability can be achieved by the equipments.

   3.2 The test environments may include nuclear blast, thermal radiation, initial nuclear radiation (gamma and neutrons), low-altitude electromagnetic pulse, high altitude electromagnetic pulse and x-rays, where applicable.

4. APPROVAL DATE: 1 NOVEMBER 1983

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR): SLCHD-NW-P

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for nuclear survivability in the Proof-of-Principle or the Development-Production Prove-Out acquisition phase, this Data Item Description (DID) shall be listed on the Contract Data Requirements List (CDRL) using DD Form 1423 with delivery required 60 days after contract award.

   7.2 Delivery. The Government review and approval cycle normally requires delivery of this test plan at least 120 days prior to the first scheduled test. The schedule of Test Integration Working Group reviews should be taken into consideration in determining final test plan delivery requirements. When this test plan involves only piece parts, components, or materials testing, delivery can be negotiated to a minimum of 30 days prior to the first scheduled test.

   7.3 Test plans are optional for the Engineering Design Test (EDT) and the tests before EDT of piece parts, components, or materials. Test plans are mandatory for the Development Test. When formal test plans are not submitted, the developer could request that such plans be detailed in the Quarterly Technical Reports.

   7.4 Measurements of the nuclear response of electronic piece parts shall be in accordance with the methods of MIL-STD-883 and MIL-STD-750.

   7.5 When a solicitation or contract has this test plan as a requirement, then the NWE Report (DI-R-1760A) should also be listed on the DD Form 1423.

   7.6 AR 70-60, Nuclear Survivability of Army Materiel, contains the Army policy applicable to nuclear survivability. HDL-TR-1882-1, NWE on Army Tactical Systems, Vol 1, Overview, provides a comprehensive overview of NWE. HDL-CR-81-015-1, DNA 1420-H (1 and 2), DNA 2114-H (1 through 4), DNA 3286-H, and DASA 2432-H are documents that provide more specific technical information. HDL-CR-81-015-1 contains a Test Design Plan. All identified documents, except AR 70-60, are available from the Defense Technical Information Center.

8. APPROVAL LIMITATION:

9. REFERENCES: AR 70-60, HDL-TR-1882-I, HDL-CR-81-015-1, MIL-STD-883, MIL-STD-750

10. PREPARATION INSTRUCTIONS:

10.1 General. The NWE Test Plan shall provide the methods, to include test and analysis, to demonstrate that the system meets or exceeds its nuclear survivability specifications. The test plan shall be prepared consistent with the information contained in HDL-TR-1882-I, and HDL-CR-81-015-1. Where applicable, the test methods of MIL-STD-883 or MIL-STD-750 shall be used. The test plan shall include the following information:

10.2 Background.

(a) A statement of how these tests support the system validation and the need for each nuclear environment test, considering existing data and the system's functional requirements.

(b) A discussion of critical issues, trade-off alternatives, and risks associated with the nuclear survivability tests.

(c) A discussion of what considerations the contractor has made for the interactions of the Government-Furnished Equipment (GFE) with the Contractor Furnished Equipment (CFE) and the consequent impact of these considerations on this test plan.

10.3 Specific Tasks.

(a) A listing of piece parts, materials, components, circuits, structures, subassemblies, assemblies, and systems to be tested with detailed information concerning tests and parameters to be measured before, during, and after the nuclear environment tests (the test data sheet must be included in this plan); monitor points and rationale for choices; instrumentation for sample response measurements to be employed; ambient conditions; modes of test sample function during the environment test with rationale; number of test samples and controls; the physical orientations of the samples to the test environment (for system level tests, this includes GFE and CFE orientations); the number and kinds of spare parts and GFE required (simulation facilities should not be considered GFF); and the data to be recorded. The plan for the test data analysis shall be detailed. Particular emphasis shall be given to hardness critical items (HCI) and to mission essential equipment. An HCI is a hardware item at any indenture level which is mission critical and could be designed, repaired, substituted, manufactured, installed or maintained for normal operation and yet degrade system hardness in a nuclear environment if hardness were not considered. (See DoD-STD-100).

(b) A description of the test facilities to be employed to include special instrumentation and simulator characteristics (include for ionizing radiation environments, the radiation type, beam energy and pulse width), environment measurement techniques, and calibration procedures. The justification for choosing the simulators or simulation techniques including the pertinent simulator characteristics being sought shall be presented.

(c) A decription of how the chosen simulator environments resemble and differ from the threat environments and how these differences are going to be dealt with.

(d) A statement of the specific test levels and test sequences each with an assigned priority to be employed in each environment test and the time between the irradiation and the parameter measurements. Remote operation and monitoring of equipment shall be shown in detail.

10.4 Data Analysis.

(a) A discussion of acceptability criteria for the test data, considering operational impact, error budget, and allowable downtime, for example.

(b) The methodology of interpolation or extrapolation of test exposures or environments to a calculation or analysis of how the system responds to the threat criteria.

10.5 Miscellaneous.

(a) The sequence of the nuclear environment tests and the specifics of the test schedule (months after award of contract, duration of tests, and transportation time between facilities).

(b) The job categories and the number of people required for each test.

(c) Additional information necessary to adequately delineate the planned NWE Test.

DATA ITEM DESCRIPTION # DI-R-1760A

1. TITLE: NUCLEAR WEAPONS EFFECTS TEST REPORT

2. IDENTIFICATION NUMBER: ARMY, # DI-R-1760A

3. DESCRIPTION /PURPOSE:

3.1 The Nuclear Weapons Effects (NWE) Test Report documents the results of tests performed on systems, subsystems, structures, circuits, components, materials, and piece parts and provides the engineering evaluation of the system's nuclear survivability.

3.2 The test environments may include nuclear blast, thermal radiation, initial nuclear radiation (gamma and neutrons), low-altitude electromagnetic pulse, high altitude electromagnetic pulse and x-rays, where applicable.

4. APPROVAL DATE: 1 NOVEMBER 1983

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR): SLCHD-NW-P

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

7.1 Application. When a solicitation or contract contains a requirement for nuclear survivability in the Proof-of-Principle or the Development-Production Prove-Out acquisition phase, this Data Item Description (DID) shall be listed on the Contract Data Requirements List (CDRL) using DD Form 1423.

7.2 Delivery. A separate test report for each test delineated in the NWE Test Plan (DI-R-1759) or a consolidated test report for all the tests is the option of the procuring activity. The NWE Test Report(s) shall be submitted 30 days after completion of the test(s).

7.3 Formal test report(s) are optional for the Engineering Design Test (EDT) and for the tests before EDT. When these tests are performed, the Quarterly Technical Progress Reports can be used as the vehicle for reporting the results and evaluation. Test report(s) are mandatory for the Development Test.

7.4 When a solicitation or contract has this test plan as a requirement, then the NWE Test Plan (DI-R-1759A) should also be listed on the DD Form 1423.

7.5 AR 70-60, Nuclear Survivability of Army Materiel, contains the Army policy applicable to nuclear survivability. HDL-TR-1882-I, NWE on Army Tactical Systems, Vol. 1, Overview, provides a comprehensive overview of NWE. HDL-CR-81-015-1, DNA 1420-H (1 and 2), DNA 2114-H (1 through 4), DNA 3286-H, and DASA 2432-H are documents that provide more specific technical information. All identified documents, except AR 70-60, are available from the Defense Technical Information Center.

7.6 The DD Form 1423 should list W71BFJ (Office Symbol SLCHD-NW-P) as a recipient of DI-R-1760A so that the Special Data (para 10.5) can be entered into the DoD Component Response Information Center (CRIC), which is maintained by the Harry Diamond Laboratories of the U.S. Army Laboratory Command.

8. APPROVAL LIMITATION:

9. REFERENCES: AR 70-60,(01 NOVEMBER 1977)

10. PREPARATION INSTRUCTIONS:

10.1 General. The NWE Test Report shall contain all the data and conclusions resulting from the test(s) delineated in the NWE Test Plan and shall include the following information:

10.2 Specific Data.

(a) Documentation with raw data of the preirradiation and postirradiation or exposure measurements on the piece parts, materials, components, circuits, structures, subassemblies, assemblies, and systems tests. There shall be particular emphasis on identifying and reporting the test results for the hardness critical items (HCI) and to mission-essential equipments. An HCI is a hardware item at any indenture level which is mission-critical and could be designed, repaired, substituted, manufactured, installed, or maintained for normal operation and yet degrade system hardness in a nuclear environment if hardness were not considered. (See DoD-STD-100).

(b) Documentation of the test conditions for these measurements, including but not limited to, the ambient conditions, the instrumentation for the measurements, the monitor points, the time relation of the measurements with respect to the radiation or exposure, modes and conditions of the test sample function during the radiation or exposures and during the measurements, physical orientations of the test samples to the test environments (for system level tests, these include the Government and contractor-furnished equipments), time after exposure that the measurements are made and the measurements of the simulated environments.

(c) A statement of how the simulated environments were measured at locations where measurements with respect to the sample were made and what devices or instruments were used.

(d) A detailed description of the instrumentation calibration procedures.

(e) Detailed test data sheets for each exposure with the concurrence signatures of the Government observers and the contractors.

10.3 Operational Data.

(a) Specification of the system operational steps used to set up the system for tests.

(b) Details of the equipment post exposure status and the procedures used to restore the system to full function after the radiation or exposure.

10.4 Data Analysis.

(a) A discussion of acceptability criteria for the test data, considering operational impact, error budget, and allowable downtime, for example.

(b) As appropriate, a detailed description of how the response information on piece parts, materials, components, circuits, structures, subassemblies, and assemblies is analyzed to arrive at an evaluation of the system survivability.

(c) Details of the calculations and analysis for the interpolation or extrapolation of the test data to determine how the system responds to the threat criteria. Computer analysis codes shall be named and referenced. All configurations, vehicles, and enclosures for these equipments shall be included in the NWE evaluations.

(d) A statement of whether the system is considered survivable per the specifications of the contract and the rationale for this conclusion.

(e) A statement of the plan or modifications and schedule proposed where the system does not meet the nuclear survivability specifications of the contract.

(f) In the data analysis discussions, clearly identify the assumptions, opinions and judgments made to support the conclusions.

10.5 Special Data. The NWE Test Report shall provide the data listed below for the neutron, total dose, and dose rate responses of piece parts and shall have the heading Response Data for the Component Response Information Center.

(a) Description of device tested.

(1) Type number to include complete MIL-STD- part designations, as appropriate (e.g., 2N2930 JTX, M38510/00101BAC).

(2) For special devices, the closest commercial equivalent type number.

(3) Device class (for example, diode, transistor, or linear or digital integrated circuit).

(4) Manufacturer.

(5) Device test sequence identification number.

(6) Manufacturer's lot number, if available.

(7) Data code or purchase date.

(8) Number of samples tested.

(b) Neutron and total dose effects data.

(1) Parameters measured, operating points (for example, h sub FE with I sub C and V sub CE operating points), time between irradiation and measurement, and how measurements were made.

(2) Test facility.

(3) Test date.

(4) Bias during irradiation.

(5) Irradiation temperature and test temperature.

(6) Test data for each piece part at each radiation level.

(7) Total dose (rad(Si)) or neutron fluence (n/cm sq [1 MeV equivalent damage in Si]). For total dose measurements, the radiation type and energy and the duration of the irradiation(s) must be specified.

(c) Ionizing dose-rate effects data:

(1) Same information as 10.5(b), Items 1 through 7.

(2) Pulse width.

(3) Photocharge in coulombs or photocurrent in milliamperes.

(4) Dose level in rad(Si) or dose rate in rad(Si)/second.

(5) Relaxation time.

DATA ITEM DESCRIPTION # DI-R-1761A

1. TITLE: NUCLEAR SURVIVABILITY DESIGN PARAMETERS REPORT

2. IDENTIFICATION NUMBER: A..MY, # DI-R-1761A

3. DESCRIPTION /PURPOSE:

3.1 This report describes the system features that constitute and control the system's NWE Survivability.

3.2 Documenting these features from the earliest phases of the acquisition process will support the system's NWE survivability during production, assist in retaining survivability during system maintenance and overhaul, aid in retaining survivability during product improvements and engineering change proposals, and preserve the operational procedures related to NWE survivability.

4. APPROVAL DATE: 1 NOVEMBER 1983

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR): SLCHD-NW-P

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

7.1 Application. When a solicitation or contract contains a requirement for nuclear survivability in the Proof-of-Principle or the Development-Production Prove-Out acquisition phase or any subsequent acquisition phase, this Data Item Description (DID) shall be listed on the Contract Data Requirements List (CDRL) using DD Form 1423.

7.2 Delivery. This report shall be required in the first acquisition phase where NWE survivability is a requirement. Subsequent acquisition phases shall also require this report. In these subsequent acquisition phases, this report should be based on previous submissions with updating to reflect the system modifications that impact the NWE survivability. A draft report shall be delivered no later than 180 days prior to contract completion for a program acquisition greater than 18 months. For a program acquisition phase less than 18 months, this report shall be delivered no later than 90 days before contract completion. The final report is due within 30 days after completion of the Government's review.

7.3 Interrelationship. The information in this report is the basis for the Nuclear Survivability Assurance Plan (DI-R-1762A) and the Nuclear Survivability Maintenance and Surveillance Plan (DI-R-1763A). This data can also be used for Detailed Test Plans, Functional Configuration Audits, Physical Configuration Audits, Configuration Items, Allocated Configuration Identification, Repair Parts and Special Tools List, Logistic Plans, Field Manuals, Technical Manuals and Producibility, Engineering, and Planning. Some of the data in this report should be drawn from the output of the Nuclear Survivability Program Plan (DI-R-1758A). Therefore, when a solicitation or contract has this report as a requirement, the Nuclear Survivability Program Plan (DI-R-1758A) shall also be listed on DD Form 1423.

7.4 AR 70-60, Nuclear Survivability of Army Materiel, contains the Army policy applicable to nuclear survivability. HDL-TR-1882-1, NWE on Army Tactical Systems, Vol. 1, Overview, provides a comprehensive overview of NWE. HDL-CR-81-015-1, DNA 1420-H (1 and 2), DNA 2114-H (1 through 4), DNA 3286-H, and DASA 2432-H are documents that provide more specific technical information. HDL-CR-81-015-1 contains a Test Design Plan. All identified documents, except AR 70-60, are available from the Defense Technical Information Center.

8. APPROVAL LIMITATION:

9. REFERENCES: AR 70-60,(01 NOVEMBER 1977), DoD-STD-100

10. PREPARATION INSTRUCTIONS:

10.1 Unless otherwise stated in the solicitation, the effective date of the document(s) cited in this block shall be that listed in the issue of the DoD Index of Specifications and Standards (DODISS) and the supplements thereto specified in the solicitation and will form a part of this DID to the extent defined herein.

10.2 General. The Nuclear Survivability Design Parameters Report shall contain a detailed description of those features of the system that constitute and control the system's nuclear survivability. As applicable, some of the data for this report shall be drawn from the Nuclear Survivability Program Plan. If the Nuclear Survivability Design Parameters Report was a requirement in the preceding acquisition phases, these reports shall form the basis for the current report. All contractor-furnished equipment, to include proprietary materials, components or equipment shall be included in this report. The report shall include the following information:

10.3 Assumptions.

(a) Any assumptions that were made in the interpretation of the nuclear survivability criteria, the system's operational specifications during or after the nuclear event, the various configurations, vehicles and enclosures that affect the system's nuclear response, and the Government-Furnished Equipment (GFE) associated with the system.

(b) The assumptions concerning the deployment and the operation of the equipment as in these examples: (1) assumed modification of the environments enclosures or vehicles, (2) operator functions that are expected to be performed during routine setup to ameliorate the effects of the nuclear environments, (3) operator functions that are expected to be performed after a nuclear event to restore the equipment to full operational capability.

10.4 Specific Information.

(a) The identification of the system, assembly, circuit, module, component, piece part, or material parameters that are critical to the system's operation in the specified nuclear environments, including both the specification of these parameters in detail and the limits of acceptable variation of these parameters. Provide the specific levels of degradation that can be tolerated for each hardness critical item (HCI) and for each specific circuit, configuration or applications of such in the system. A hardness critical item at any indenture level which is mission-critical and could be designed, repaired, substituted, manufactured, installed or maintained for normal operation and yet degrade system hardness in a nuclear environment if hardness were not considered. The drawings and the documentation where these appear shall be marked with the notation HCI (Ref. DoD-STD-100). Where there is a process, procedure or specification which is critical to the system nuclear survivability, and which, if changed, could satisfy normal operational requirements and yet degrade system survivability if not considered, these shall be designated hardness critical processes (HCP) and shall be so identified in the system drawings and documents (Ref. DoD-STD-100).

(b) A statement of the rationale for the choice of these designs, identifying particular parameters with the appropriate parts of the nuclear survivability criteria environment and explaining the association of these parameters with these environments.

(c) All tests, calculations, or analyses that support the choice of these parameters.

(d) Considerations made in the design phase to specifically exclude certain designs, piece parts or piece part technologies, components, or materials.

10.5 Typical Information.

(a) For transient radiation effects: The critical semiconductor parameters, the selection or the exclusion of specific device technologies, specific circuit design considerations, feedback, current limiting, circuit parameters, and subassembly parameters.

(b) For electromagnetic pulse (EMP): Shielding effectiveness parameters, shielding design, filter and arrestor designs, choice of cables, connectors, the assumptions concerning EMP coupling sources and the system's GFE, the system's configurations that were considered in the analysis, and the methods used and the assumptions made in the system's response analysis.

(c) For blast: Critical structural members or designs, mechanical details of the structure that provide protection against dust, impact, shock, and the considerations given for the blast-thermal synergism.

(d) For thermal radiation: The identification of critical external components and the worst-case analysis of the response of these parts, to include the operational impacts.

10.6 Impacts. The Nuclear Survivability Design Parameters Report shall document the operational or functional consequences of each of the nuclear survivability measures cited.

DATA ITEM DESCRIPTION # DI-R-1762A

1. TITLE: NUCLEAR SURVIVABILITY ASSURANCE PLAN

2. IDENTIFICATION NUMBER: ARMY, # DI-R-1762A

3. DESCRIPTION /PURPOSE:

   The Nuclear Survivability Assurance Plan describes the methods to preserve a system's NWE survivability during the production acquisition phase.

4. APPROVAL DATE: 1 NOVEMBER 1983

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR): SLCHD-NW-P

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for nuclear survivability in the Proof-of-Principle or the Development-Production Prove-Out acquisition phase, this Data Item Description (DID) shall be listed on the Contract Data Requirements List (CDRL) using DD Form 1423.

   7.2 Delivery. The delivery of this NWE Assurance Plan shall be no later than 90 days before the completion of the contract to allow for Government evaluation and comments.

   7.3 When this NWE Assurance Plan is implemented in a production contract, resultant data shall be reported via the Test Report (DI-T-5247). The DD Form 1423 shall require delivery of the Test Report (DI-T-5247) consistent with the schedule delineated in this NWE Assurance Plan.

   7.4 Modifications to the system during the production phase may require changes to the Nuclear Survivability Assurance Plan. A nuclear survivability expert shall review the change proposals for their impact on the system survivability and on this assurance plan. This expert shall be assigned the responsibility for recommending the appropriate modifications for insertion into the assurance plan.

   7.5 This assurance plan shall be based on the Nuclear Survivability Design Parameters Report which shall also be listed on the DD Form 1423.

   7.6 AR 70-60, Nuclear Survivability of Army Materiel, contains the Army policy applicable to nuclear survivability. For initial nuclear radiation, specific guidelines are provided in HDL-CR-81-015-1, available from the Defense Technical Information Center.

8. APPROVAL LIMITATION:

9. REFERENCES: AR 70-60,(01 NOVEMBER 1977)

10. PREPARATION INSTRUCTIONS:

    10.1 General. The Nuclear Survivability Assurance Plan shall describe tests, procedures, test methods, test schedules, special test equipment, and data analysis methods that are required to ensure that the system's nuclear survivability is maintained at an acceptable level during production of the system. The assurance plan shall be based on data from the Nuclear Survivability Design Parameters Report, shall include all contractor-furnished equipments including proprietary materials, components or equipment, and shall include the following information:

10.2 Background.

(a) A discussion of how the proposed assurance plan assures the system's nuclear survivability during production.

(b) A statement of how this assurance plan relates to the reliability and quality assurance programs, noting any incompatibility of these programs with the Nuclear Survivability Assurance Program.

(c) A discussion of the most critical aspects of this assurance plan, the consequences of alternative approaches considered, and the risks associated with the recommended approach.

10.3 Specific Tasks.

(a) A listing of piece parts, materials, components, circuits, structures, assemblies, subassemblies, and systems to be tested with detailed information concerning tests and parameters to be measured; monitor points and rationale for choices; ambient conditions; modes of test sample operation during the test with the rationale; sample size; numbers and kinds of Government-furnished equipment (GFE) and/or facilities required; interface requirements or interaction of a subassembly with the rest of the system, which includes GFE and contractor-furnished equipment (CFE); and the data to be recorded.

(b) A description of the test instrumentation or facilities to be employed to include special instrumentation, measurement techniques, and calibration procedures.

(c) A statement of the specific parameter values and qualities to be measured and maintained; a discussion of the specific corrective action where these values and qualities are not maintained.

(d) The methodology to be utilized for interpolation or extrapolation of test results to an assessment of how the system responds to the specific environments.

(e) The sequence of the tests, the data analysis, and the specifics of the schedule to be followed, including, but not limited to, the frequency of tests, the time between testing and analysis, reporting schedules, and when the various steps are to be initiated.

(f) The quantity and the caliber of labor required for testing and analysis.

(g) When first article tests are not included in this plan, a specific justification shall be provided.

DATA ITEM DESCRIPTION # DI-R-1763A

1. TITLE: NUCLEAR HARDNESS MAINTENANCE/SURVEILLANCE PLAN

2. IDENTIFICATION NUMBER: ARMY, # DI-R-1763A

3. DESCRIPTION /PURPOSE:

The Nuclear Hardness Maintenance/Surveillance Plan describes the special precautions needed during operation, maintenance, and repair to assure that the system's nuclear survivability is not degraded and to describe the inspection and test procedures used during the operational deployment phase to verify that the system's nuclear survivability is not degraded.

4. APPROVAL DATE: 1 NOVEMBER 1983

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR): SLCHD-NW-P

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

7.1 Application. When a solicitation or contract contains a requirement for nuclear survivability in the Proof-of-Principle or the Development-Production Prove-Out acquisition phase, this Data Item Description (DID) shall be listed on the Contract Data Requirements List (CDRL) using DD Form 1423.

7.2 Delivery. The schedule for delivery of the Nuclear Hardness Maintenance/Surveillance Plan shall be consistent with the delivery of training/technical manuals and logistics support documentation. Delivery shall be no later than 90 days before contract completion or initial operational capability (IOC), whichever occurs first.

7.3 Portions of the Nuclear Hardness Maintenance/Surveillance Plan are used in the preparation of training/technical manuals and other logistics support documentation. Therefore, the solicitation and contract shall require incorporation of data from the Nuclear Hardness Maintenance/Surveillance Plan into the final version of the training/technical manuals and other logistics support documentation.

7.4 During the Production acquisition phase, the final version of the Nuclear Hardness Maintenance/Surveillance Plan shall include all production engineering changes which impact the system's nuclear survivability.

7.5 The Nuclear Hardness Maintenance/Surveillance Plan shall be based on the Nuclear Survivability Design Parameters Report (DI-R-1761A) and the Nuclear Survivability Assurance Plan (DI-R-1762A).

7.6 AR 70-60, Nuclear Survivability of Army Materiel, contains the Army policy applicable to nuclear survivability. AWFL-TR-76-147, HDL-TR-1882-1 and 2, and HDL-CR-81-015-1 are reference documents that provide background information. All identified documents, except AR 70-60, are available from the Defense Technical Information Center.

8. APPROVAL LIMITATION:

9. <u>REFERENCES</u>: AR 70-60

10. <u>PREPARATION INSTRUCTIONS</u>:

10.1 <u>General</u>. The Nuclear Hardness Maintenance/Surveillance Plan shall describe the operational procedures, design features, materials, and piece parts that control the system's nuclear survivability; shall delineate how these shall be preserved during operation, maintenance, repair, and product improvement of the system; and shall delineate how the system's nuclear survivability can be periodically verified during deployment. The Nuclear Maintenance/Surveillance Plan shall be based on data from the Nuclear Survivability Design Parameters Report and the Nuclear Survivability Assurance Plan and shall include the following:

10.2 <u>Degradation Prevention Techniques</u>. The techniques used to prevent degradation of the nuclear survivability of the system in normal operations, maintenance, repair or product improvement, to include, but not limited to, the technologies, designs, piece parts selected for the system based on nuclear survivability considerations and the rationale for these choices.

10.3 <u>Exclusion Considerations</u>. The specific considerations used to exclude certain designs, piece parts or piece part technologies, components, or materials, including the reason for these exclusions.

10.4 <u>Critical Aspects</u>. A discussion of the most critical aspects of this maintenance/surveillance plan, the consequences of alternative approaches considered, and the risks associated with the recommended approach.

10.5 <u>Operational Considerations</u>. The nuclear hardness operational considerations shall include:

(a) The operating procedures which are necessary before a nuclear event to assure an acceptable nuclear response of the system. These shall include deployment guidelines, protective procedures (such as orientation of the equipment, configuration of the various items of the system), protective devices (such as canvas and shelters), and the readiness availability requirements for the reparable/replaceable parts, modules, or components which are vulnerable to the nuclear event.

(b) The operating procedures which would be necessary after a nuclear event, such as cycling the system power, replacing fuses or other components, resetting circuit breakers, and reloading logic data.

10.6 <u>Hardware Considerations</u>. Identification of the assemblies, subassemblies, circuits, modules, components, piece parts, materials, and processes that are critical to the system's survival in a nuclear environment, the specific parametric values or qualities to be maintained for these items and the methods for maintaining them. The drawings and the documentation where these items appear shall be marked with the notation HCI, for hardness critical item, or HCP, for hardness critical process (Ref. DoD-STD-100).

10.7 <u>Surveillance/Verification Procedures</u>. The nuclear hardness surveillance procedures shall include:

(a) A description of the inspection and test procedures, facilities to be employed, special instrumentation, measurement techniques, calibration procedures, test methods and data analysis, and specifics of the schedule to be followed. The specifics of the schedule shall include the time after deployment before the initiation of the various actions, the frequency of testing and inspection, the reporting schedule, and the timing of this surveillance schedule with respect to the normal maintenance schedule.

(b) A listing of piece parts, materials, components, circuits, structures, assemblies, subassemblies, and systems to be checked with detailed information concerning inspections and tests to be performed, monitor points and rationale for choices; ambient conditions; modes of test sample operation and sample configuration during the test with rationale; sample size, the number and kinds of Government furnished equipment required; the interface requirements or the interaction of the test item with the rest of the system; and the data to be recorded.

(c) The acceptability criteria for the tests and remedial actions where the acceptability criteria are not met.

(d) The methodology for interpolation or extrapolation of test results to an assessment of how the system responds to the specified environments.

(e) The quantity and caliber of labor required to implement the surveillance procedures.

SECTION 2. NBC CONTAMINATION SURVIVABILITY DATA ITEM DESCRIPTIONS

DATA ITEM DESCRIPTION # DI-R-1778

1. TITLE: NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION SURVIVABILITY PROGRAM PLAN

2. IDENTIFICATION NUMBER: ARMY, # DI-R-1778

3. DESCRIPTION/PURPOSE:

   3.1 The NBC Contamination Survivability Program Plan describes how the contractor's NBC Contamination Program will be conducted. It describes the design, analyses, test, and management activities to be performed to satisfy the NBC contamination survivability criteria for contaminants and decontaminants.

   3.2 This plan provides the basis for the Government's determination that the contractor's NBC Contamination Survivability Program will meet contractual requirements in a cost-effective manner.

4. APPROVAL DATE: 15 July 1985

5. OFFICE OF PRIMARY RESPONSIBILITIES: DELNV

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for NBC contamination survivability in the demonstration and validation phase and/or the full-scale development phase (RDTE categories 6.3 and 6.4 as defined in AR 70-1), this data item shall be listed on the Contract Data Requirements List (DD Form 1423) with delivery required 60 to 90 days after contract (DAC) award.

   7.2 AR 70-71, Nuclear, Biological, and Chemical (NBC) Contamination Survivability of Army Materiel, contains the Army policy applicable to NBC contamination survivability.

   7.3 SPC 810, Nuclear, Biological, and Contamination Survivability Standards Study (U), Final Report dated August 1982, provides NBC contamination survivability criteria and background information. This classified document is available from the Defense Technical Information Center (DTIC), accession number ACDO29937.

   7.4 The nuclear portion of NBC contamination survivability is limited to residual radiological contamination in the form of fallout, rainout, and neutron-induced gamma activity. Nuclear survivability concerned with initial nuclear weapons effects, such as electromagnetic pulse (EMP), is addressed in AR 70-60, Nuclear Survivability of Army Materiel. The DIDs related to AR 70-60 are:

      DI-R-1758, Nuclear Survivability Program Plan

      DI-R-1759, Nuclear Weapons Effects Test Plan

      DI-R-1760, Nuclear Weapons Effects Test Report

      DI-R-1761, Nuclear Survivability Design Parameters Report

      DI-R-1762, Nuclear Survivability Assurance Plan

DI-R-1763, Nuclear Survivability Maintenance Plan

7.5 This DID is directly related to:

DI-R-1781, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Design Parameters Report

DI-R-1779, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Test Plan

DI-R-1780, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Test Report

DI-R-1782, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Assurance Plan

DI-R-1783, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Maintenance Plan

DI-R-1784, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Final Report

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8. APPROVAL LIMITATION:

9A. REFERENCES: AR 70-1, AR 70-60, AR 70-71, SPC 810

9B. MCSL NUMBER: AMSC #: A3643

10. PREPARATION INSTRUCTIONS:

10.1 General. The NBC Contamination Survivability Program Plan shall delineate the methods and the techniques for incorporating NBC contamination survivability into design and development and for conducting a comprehensive NBC contamination survivability validation program. The plan shall be prepared consistent with the information contained in SPC 810 and shall include, at a minimum, the following information:

10.2 Specific Tasks.

(a) The specific tasks necessary for design, analyses, test, evaluation, and management of NBC contamination survivability requirements.

(b) Preparation and approval of a time and event schedule for the initiation, review, and accomplishment of each specific task.

(c) Identification of the parts, materials, facilities, equipments, subsystems, and systems requirements for each specific task.

(d) The estimated labor hours, the caliber of labor, and cost(s) required (such as labor, material, travel, computer, and simulation facility).

10.3 Design, Analyses, Tests, and Evaluations.

(a) The delineation of analytical efforts that supplement or replace testing to include the identification of computer software simulation(s), and the ways that these and other analytical techniques will be used.

(b) Piece part, component, and subsystem tests to be performed for the appropriate NBC contamination environments, with details such as numbers of samples, test methods, test instrumentation, and parameters to be characterized.

(c) System level tests to be performed, including the method of extrapolation from the test environment to the threat environment, and the rationale for simulants choice.

(d) Simulants to be employed, test configurations, exposure levels, test data to be obtained, and their relationship to analytical efforts.

(e) The NBC contamination survivability design philosophy to include the basis for selection of materials, finishes, device technologies, circuit/mechanical designs; assumptions concerning the system design margins, contaminants and decontaminants, planned operational fixes, and any assumptions concerning system/subsystem/equipment operation, function, deployment or configuration that has been used in developing the NBC Contamination Survivability Program.

(f) The application of NBC Contamination Survivability Program results to the production and maintenance of the deployed system/subsystem/equipment.

(g) The projected requirements, driven by the NBC Contamination Survivability Program of the system/subsystem/equipment, for special or custom parts, materials, components, finishes, or processes; the basis of need for these requirements; and the impacts of these requirements on the development program and design, costs, operation, maintenance, function, or deployment.

10.4 Risk Analysis and Identification:

(a) The identification of NBC contamination survivability areas of high risk and uncertainty.

(b) The identification of assumptions, conclusions, and reasons used in risk analysis and identification.

(c) The identification of actions to be taken to minimize impact of risk and uncertainties identified.

(d) Methodology and procedures by which the prime contractor will ensure NBC contamination survivability meeting the policy requirements of AR 70-71 are contained in subcontracts.

(e) The identification of actions to be taken to ensure NBC contamination survivability for material to be developed elsewhere, such as commercial off-the-shelf items and performance-type military specification items.

(f) The identification of special requirements to be included in the source or product selection criteria.

(g) An indication of contractor's improvement action(s) when an item does not meet system or material requirements.

(h) A definition of the interactions of the noncontractor-developed equipments with the contractor-developed equipments and the approach to integrating the NBC contamination survivability of these equipments.

10.5 Management Interface Controls:

The interface between the NBC Contamination Survivability Program and other related programs, such as nuclear survivability, engineering design, reliability, maintainability, human factors engineering, quality assurance, standardization production engineering, and producibility programs.

10.6 Program Management:

(a) The identification of the NBC Contamination Survivability Program Manager having responsibility for the NBC Contamination Survivability Program.

(b) Management procedures and controls available to assure the successful application and accomplishment of NBC contamination survivability requirements.

10.7 Government Participation:

The plan shall identify parts, materials, facilities, equipments, subsystems, systems, or data that the contractor desires the Government to provide as part of the NBC Contamination Survivability Program.

10.8 Miscellaneous:

Any additional information that may be necessary to adequately delineate the NBC Contamination Survivability Program.

DATA ITEM DESCRIPTION # DI-R-1779

1. TITLE: NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION SURVIVABILITY TEST PLAN

2. IDENTIFICATION NUMBER: ARMY, DI-R-1779

3. DESCRIPTION/PURPOSE:

3.1 The NBC Contamination Survivability Test Plan prescribes the general procedures, items, and conditions governing the planning, preparation, implementation, and reporting of NBC contamination effects testing that will constitute adequate proof, when combined with other data and analysis, that an acceptable level of NBC contamination survivability can be achieved by the equipment.

3.2 The test environment will include the nuclear, biological, and chemical contamination and decontamination hazards defined in the NBC contamination survivability criteria.

4. APPROVAL DATE: 15 JULY 1985

5. OFFICE OF PRIMARY RESPONSIBILITY: DELNV

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

7.1 Application. When a solicitation or contract contains a requirement for NBC contamination survivability in the demonstration and validation phase and/or the full-scale development phase (RDTE categories 6.3 and 6.4 as defined in AR 70-1), this data item shall be listed on the Contract Data Requirements List (DD Form 1423).

7.2 Delivery. The Government's review, comment, and approval cycle normally requires delivery of the plan at least 120 days prior to the first scheduled test. The schedule of Test Integration Working Group reviews should be taken into consideration in determining final test plan delivery requirements. When the test plan involves only piece parts, components, or materials testing, delivery can be negotiated to a minimum of 30 days prior to the first scheduled test.

7.3 Test plans are optional for the Engineering Design Test (EDT) and tests before EDT of piece parts, components, or materials. Test plans are mandatory for the development test.

7.4 When a solicitation or contract has this DID as a requirement, then the NBC Survivability Test Report (DI-R-1780) shall also be listed on the Contract Data Requirements List (DD Form 1423).

7.5 AR 70-71, Nuclear, Biological, and Chemical (NBC) Contamination Survivability of Army Materiel, contains the Army policy applicable to NBC contamination survivability.

7.6 SPC 810, Nuclear, Biological, and Chemical Contamination Survivability Standards Study (U), Final Report dated August 1982, provides NBC contamination survivability criteria and background information. This classified document is available from the Defense Technical Information Center (DTIC), accession number ADCO29937.

7.7 The nuclear portion of NBC contamination survivability is limited to residual radiological contamination in the form of fallout, rainout, and neutron-induced gamma activity. Nuclear survivability concerned with initial nuclear weapons effects such as blast, thermal radiation, and electromagnetic pulse (EMP) is addressed in AR 70-60.

7.8 In addition to the DIDs referenced in paragraph 7.3, this DID is also directly related to:

DI-R-1778, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Program Plan

DI-R-1780, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Test Report

DI-R-1781, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Design Parameters Report

DI-R-1782, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Assurance Plan

DI-R-1783, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Maintenance Plan

DI-R-1784, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Final Report

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8. APPROVAL LIMITATION:

9A. REFERENCES: AR 70-1, AR 70-60, AR 70-71, SPC 810, MIL-STD-810D, MIL-STD-883C

9B. MCSL NUMBER: AMSC#: A3644

10. PREPARATION INSTRUCTIONS:

10.1 General. The NBC Contamination Survivability Test Plan shall provide the methods, to include test and analysis, to demonstrate that the system/subsystem/equipment meets or exceeds its NBC specifications. The test plan shall be prepared consistent with the information contained in SPC 810. Where applicable, the test methods of MIL-STD-810D and MIL-STD-883C shall be used. The test plan shall include, at a minimum, the following information:

10.2 Background.

(a) A statement of how these tests will support the system/subsystem/equipment validation and the need for each NBC environment test, considering existing data and the system/subsystem/equipment's functional requirements.

(b) A discussion of critical issues, trade-off alternatives, and risks associated with the NBC contamination survivability test.

(c) A discussion of what consideration the contractor has made for the interactions of the Government-Furnished Equipment (GFE) on the Contractor-Furnished Equipment (CFE), and the consequent impact of these considerations on the testing, methodologies, processes, and techniques prescribed by this test plan.

10.3 Specific Tasks.

(a) A listing of piece parts, materials, components, circuits, structures, subassemblies, assemblies, equipments, subsystem(s), and system(s) to be tested with detailed information concerning tests and parameters to be measured before, during, and after the NBC contamination environment tests; monitor posts and rationale for choices, instrumentation for sample response measurements to be employed, ambient conditions, modes of test sample function during the environment testing with rationale; number of test samples and controls; the physical orientations of the samples to the test environments (for system level tests, this shall include GFE and CFE orientations); the number and kinds of spare parts and GFE required (simulation facilities shall not be considered GFE); and the data to be recorded.

(b) A description of the test facilities to be employed to include special instrumentation and simulants characteristics, environment measurement techniques, and calibration procedures.

(c) A description of how the chosen simulation environments resemble and differ from the threat environments.

(d) A statement of the specific NBC contamination criteria levels to be employed, and the time between contamination and decontamination, and the effects measurements.

10.4 Data Analysis.

(a) A discussion of acceptability criteria for the test data, considering operational impact, error budget, and allowable downtime, for example.

(b) The methodology of interpolation or extrapolation of test exposures or environments to a calculation or analysis of how the equipment/subsystem/system responds to the threat criteria.

10.5 Miscellaneous.

(a) The sequence of the NBC contamination/decontamination environment tests, and the specifics of the test schedule, days after contract (DAC), durations of tests, and transportation between facilities.

(b) Job/labor categories required, and the number of personnel in those categories required for each test.

(c) Any additional information that may be necessary to adequately delineate the NBC contamination/decontamination effects testing.

DATA ITEM DESCRIPTION # DI-R-1780

1. TITLE: NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION SURVIVABILITY TEST REPORT

2. IDENTIFICATION NUMBER: ARMY, DI-R-1780

3. DESCRIPTION/PURPOSE:

   The NBC Contamination Survivability Test Report shall document the results of tests performed on parts, components, materials, processes, equipments, subsystems, and/or systems as applicable, and shall provide information that will enable the Government to evaluate and determine subsequent actions.

4. APPROVAL DATE: 15 JULY 1985

5. OFFICE OF PRIMARY RESPONSIBILITY: DELNV

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for NBC contamination survivability in the demonstration and validation phase and/or the full-in scale development phase (RDTE categories 6.3 and 6.4 as defined in AR 70-1), this data item shall be listed on the Contract Data Requirements List (DD Form 1423). The delivery date shall be defined on the DD Form 1423.

   7.2 When the NBC Contamination Survivability Assurance Plan (DI-R-1782) is implemented in a production contract, the resultant data shall be reported via this data item.

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8. APPROVAL LIMITATION:

9A. REFERENCES: AR 70-1, DI-R-1780, DI-R-1779, DI-R-1782

9B. MCSL NUMBER: AMSC#: A3645

10. PREPARATION INSTRUCTIONS:

   10.1 The contractor shall compile and submit all necessary test data in a format consistent with the manner of presentation approved in the NBC Contamination Survivability Test Plan (DI-R-1779) and/or the NBC Contamination Survivability Assurance Plan (DI-R-1782). The test report shall demonstrate the degree to which the test item(s) meet all performance specifications of the contract. The test data shall identify the parts, components, subassemblies, assemblies, equipments, subsystems, or systems tested, and shall be complete so as to permit duplication of all tests for those configurations of equipments, subsystems, or systems, which exist at any time.

10.2 Test report(s) shall contain all the collected data and all conclusions resulting from tests for various configurations/designs. Each test shall be clearly identified with supporting test procedures, identified test equipment, appropriate drawings, etc., and the results attained before a major configuration/approach may be altered.

10.3 The test report must be certified by the signature of a responsible project representative of the contracting company as identified in the Government approved NBC Contamination Survivability Program Plan (DI-R-1778) in order to be considered an acceptable document by the Government.

DATA ITEM DESCRIPTION # DI-R-1781

1. TITLE: NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION SURVIVABILITY DESIGN PARAMETERS REPORT

2. IDENTIFICATION NUMBER: ARMY, DI-R-1781

3. DESCRIPTION/PURPOSE:

3.1 This report describes those features that constitute and control a system/subsystem/equipments NBC contamination survivability.

3.2 Documenting these features from the earliest phases of the acquisition process will support the system/subsystems/equipments NBC contamination survivability during production, assist in retaining NBC contamination survivability during system/subsystem/equipments maintenance and overhaul, aid in retaining NBC contamination survivability during product improvement programs (PIPs) and engineering change proposals, and preserve the operational procedures related to NBC contamination survivability.

4. APPROVAL DATE: 15 JULY 1985

5. OFFICE OF PRIMARY RESPONSIBILITY: DELNV

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

7.1 Application. When a solicitation or contract contains a requirement for NBC contamination survivability in the demonstration and validation phase and/or the full-scale development phase or any subsequent acquisition phase, this data item shall be listed on the Contract Data Requirements List (DD Form 1423).

7.2 Delivery. This report shall be required in the first acquisition phase where NBC contamination survivability is a requirement. Subsequent acquisition phases shall also require this report. In these subsequent acquisition phases, the report should be based on previous submittals, with either change pages or complete revision to reflect the system/subsystem/ equipment(s) modifications that impact the NBC contamination survivability. Within a given acquisition phase, an initial report should be delivered approximately 120 days after contract (DAC) award, with additional time as necessary to provide for Government review, comment, and approval. A final update/revision of the report should be delivered no later than 60 days prior to contract completion.

7.3 Interrelationship. The information in this report is the basis for NBC Contamination Survivability Assurance Plan (DI-R-1782) and the NBC Contamination Survivability Maintenance Plan (DI-R-1783). These data can also be used for detailed test plans and procedures, Functional Configuration Audits, Physical Configuration Audits, Configuration Identification, Repair Parts and Special Tools Lists, Logistic Design Analysis, Logistic Support Analysis, Field and Technical Manuals, and engineering design, reliability and maintainability, human factors engineering, production engineering and producibility programs. Since some of the data in this report is drawn from the output of the NBC Contamination Survivability Program Plan (DI-R-1778), when a solicitation or contract has this report as a requirement, the NBC Contamination Survivability Program Plan shall be listed on the Contract Data Requirements List (DD Form 1423).

7.4 AR 70-71, Nuclear, Biological, and Chemical (NBC) Contamination Survivability of Army Materiel, contains the Army policy applicable to NBC contamination survivability.

7.5 SPC 810, Nuclear, Biological, and Chemical Contamination Survivability Standards Study (U), Final Report dated August 1982, provides NBC contamination survivability criteria and background information. This classified document is available from the Defense Technical Information Center (DTIC), accession number ADCO29937.

7.6 The nuclear portion of NBC contamination survivability is limited to residual radiological contamination in the form of fallout, rainout, and neutron-induced gamma activity. Nuclear survivability concerned with initial nuclear weapons effects such as blast, thermal radiation, and electromagnetic pulse (EMP) is addressed in AR 70-60.

7.7 In addition to the DIDs referenced in paragraph 7.3, this DID is also directly related to:

DI-R-1779, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Test Plan

DI-R-1780, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Test Report

DI-R-1784, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Final Report

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8. APPROVAL LIMITATION:

9A. REFERENCES: AR 70-1, AR 70-60, AR 70-71, SPC 810, DI-R-1778, DI-R-1781

9B. MCSL NUMBER: AMSC#: A3646

10. PREPARATION INSTRUCTIONS:

10.1 General. The NBC Contamination Survivability Design Parameters Report shall contain a detailed description of those features of the system/subsystem/equipment that constitute and control the system/subsystem/equipment(s) NBC contamination survivability. As applicable, some of the data for this report shall be drawn from the Nuclear, Biological, and Chemical (NBC) Survivability Program Plan (DI-R-1778). When a contract requires both an initial report and a final report, the final report shall incorporate all changes/revisions to the design parameters developed during contract performance. If the NBC Survivability Design Parameters Report (DI-R-1781) was required in a preceding acquisition phase, those report(s) shall form the basis for the current report. The report shall include, at a minimum, the following information:

10.2 Assumptions.

(a) Any assumptions that were made in the interpretation of the NBC survivability criteria, the system/subsystems/equipment's operational specifications during or after a nuclear event, the various configurations, vehicles and enclosures that affect the system/subsystem/equipment's NBC response, and the Government-furnished equipment (GFE) associated with the system/subsystem/equipment.

(b) The assumptions concerning the deployment and operation of the system/subsystem/equipment, as in these examples: (1) assumed modification of the environments by enclosures or vehicles, (2) operator functions that are expected to be performed during routine setup to ameliorate the effects of the NBC contaminants and environments, (3) operator functions that are expected to be performed after and NBC contaminant effect to restore the system/subsystem/equipment to full operational capability.

10.3 Specific Information.

(a) Identification of the system/subsystem/equipment, assembly, circuit, module, component, piece part, or the material parameters that are critical to the system/subsystem/equipment's operation in the specified NBC contamination environments, including both the specification of these parameters in detail, and the limits of acceptable variation of these parameters.

(b) A description of the rationale for the choice of these design parameters, identifying particular parameters with the appropriate parts of the NBC contamination survivability criteria for specific environments, and explanation of the association of the parameters with these environments.

(c) All tests, calculations, or analyses performed, with specific description of those that support the choice of those parameters.

10.4 Typical Information. The report shall contain, but not be limited to, items such as the following:

(a) For transient radiation effects: the critical semiconductor parameters, selection or exclusion of specific device technologies, specific circuit design considerations, feedback, current limiting, circuit parameters, and subassembly parameters.

(b) For neutron-induced gamma activity: this should be coordinated with the parameters and criteria established for nuclear survivability as defined in AR 70-60. In most cases, the requirements for nuclear survivability will satisfy the requirements for NBC contamination survivability.

10.5 Impacts. The report shall document the operational or functional consequences of each of the NBC contamination survivability measures cited.

DATA ITEM DESCRIPTION # DI-R-1782

1. TITLE: NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION SURVIVABILITY ASSURANCE PLAN

2. IDENTIFICATION NUMBER: ARMY, DI-R-1782

3. DESCRIPTION/PURPOSE:

   The NBC Contamination Survivability Assurance Plan describes the methods to preserve an equipment/subsystem/system's NBC contamination survivability during the production acquisition phase.

4. APPROVAL DATE: 15 JULY 1985

5. OFFICE OF PRIMARY RESPONSIBILITY: DELNV

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for NBC contamination survivability in the demonstration and validation phase and/or the full-in scale development phase, (RDTE categories 6.3 and 6.4 as defined in AR 70-1), this data item shall be listed on the Contract Data Requirements List (DD Form 1423) with delivery required no later than 60 days before the completion of the contract to allow for Government evaluation and comments.

   7.2 When this assurance plan is implemented in a production contract, resultant data should be reported via the NBC Contamination Survivability Test Report (DI-R-1780). The DD Form 1423 shall require delivery of the Test Report consistent with the schedule delineated in this assurance plan.

   7.3 Modification to the equipment/subsystem/system during the production phase may require changes to the NBC Contamination Assurance Plan. An NBC contamination survivability expert shall be tasked to review the change proposals for their impact on the equipment/subsystem/system's NBC contamination survivability and on this assurance plan. This expert shall be assigned the responsibility for recommending the appropriate modifications for insertion into the assurance plan.

   7.4 Since this assurance plan is based on the NBC Contamination Survivability Design Parameters Report (DI-R-1781), and the NBC Contamination Survivability Test Plan (DI-R-1779), they shall also be listed on the Contract Data Requirements List (DD Form 1423).

   7.5 AR 70-71, Nuclear, Biological, and Chemical (NBC) Contamination Survivability of Army Materiel, contains the Army policy applicable to NBC contamination survivability.

   7.6 SPC 810, Nuclear, Biological, and Chemical Contamination Survivability Standards Study (U), Final Report dated August 1982, provides NBC contamination survivability criteria and background information. This classified document is available from the Defense Technical Information Center (DTIC), accession number ADCO29937.

7.6 The nuclear portion of NBC contamination survivability is limited to residual radiological contamination in the form of fallout, rainout, and neutron-induced gamma activity. Nuclear survivability concerned with initial nuclear weapons effects such as blast, thermal radiation, and electromagnetic pulse (EMP) is addressed in AR 70-60.

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8. APPROVAL LIMITATION:

9A. REFERENCES: AR 70-1, AR 70-60, AR 70-71, SPC 810, DI-R-1779, DI-R-1781, DI-R-1783

9B. MCSL NUMBER: AMSC#: A3647

10. PREPARATION INSTRUCTIONS:

10.1 General. The NBC Contamination Survivability Assurance Plan shall describe procedures, test methods, special test equipment, and data analysis methods that shall be required to ensure that the equipment/subsystem/system's NBC contamination survivability is maintained at an acceptable level during production of the equipment/subsystem/system. The assurance plan shall be based on data from the NBC Contamination Survivability Design Parameters Report (DI-R-1781), and shall be in accordance with the Government-approved NBC Contamination Survivability Test Plan (DI-R-1779). The assurance plan shall include, as a minimum, the following information:

10.2 Background.

(a) A discussion of how the proposed assurance plan assures the equipment/subsystem/system's NBC contamination survivability during production.

(b) A statement of how this assurance plan relates to the reliability and maintainability programs, the NBC Contamination Survivability Maintenance Plan (DI-R-1783), and shall describe or note any incompatibility with reliability, maintainability, and the maintenance plan with the NBC contamination survivability assurance program.

(c) A discussion of the most critical aspects of this assurance plan, the consequences of alternative approaches considered, and the risks associated with the recommended approach.

10.3 Specific Tasks.

(a) A listing of piece parts, materials, components, circuits, structures, subassemblies, assemblies, equipments, subsystems, and/or systems to be tested with detailed information concerning tests and parameters to be measured; monitor points and rationale for choices; ambient conditions; modes of test sample operation during the test with the rationale; sample size; numbers and kinds of Government-furnished equipment (GFE) and/or facilities required; interface requirements or interactions of a subassembly, assembly, equipment, or subsystem with other subassemblies, assemblies, equipments, or subsystems within a system, which includes GFE and contractor-furnished equipments (CFE); and the data to be recorded.

(b) A description of the test instrumentation or facilities to be employed to include special instrumentation, measurement techniques, and calibration procedures.

(c) A statement of the specific parameter values and qualities to be measured and maintained; a discussion of the specific corrective action where these values and qualities are not maintained.

(d) The methodology for interpolation or extrapolation of test results to an assessment of how the equipment/subsystem/system responds to the specified environment.

(e) The sequence of the tests, the data analysis, and the specifics of the schedule to be followed, including but not limited to, the frequency of tests, the time between testing and analysis, reporting schedules, and when the various steps are initiated.

(f) The labor category and quantity of personnel required for testing and analysis.

DATA ITEM DESCRIPTION # DI-R-1783

1. TITLE: NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION SURVIVABILITY MAINTENANCE PLAN

2. IDENTIFICATION NUMBER: ARMY, DI-R-1783

3. DESCRIPTION/PURPOSE:

   The purpose of the NBC Contamination Survivability Maintenance Plan is twofold: (1) to describe the special precautions to be taken during regular maintenance and repair to assure that the equipment/subsystem/system's NBC contamination survivability is maintained and (2) to describe in detail those maintenance and test procedures to be used in certifying the equipment/subsystem/system's NBC contamination survivability during deployment.

4. APPROVAL DATE: 15 JULY 1985

5. OFFICE OF PRIMARY RESPONSIBILITY: DELNV

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for NBC contamination survivability in the demonstration and validation phase and/or the full-scale development phase, (RDTE categories 6.3 and 6.4 as defined in AR 70-1), this data item shall be listed on the Contract Data Requirements List (DD Form 1423) with delivery scheduled so that the Government can evaluate the maintenance plan and incorporate the data into the appropriate technical manuals and logistics support documents.

   7.2 The final version/revision of this maintenance plan shall be delivered in the production and deployment acquisition phase. This final version will comprise the maintenance plan generated in the full-scale engineering acquisition phase, with the addition of modifications that reflect the engineering changes made to the equipment/subsystem/system in production. Only those approved engineering changes that impact the equipment/subsystem/system's NBC contamination survivability will be added to the maintenance plan. The schedule of delivery of this final version of the maintenance plan will be at the discretion of the procuring activity, but shall be consistent with the delivery of the technical manuals.

   7.3 Methods, services, data, supplies, materials, designs, materials, tests, and operational procedures in the maintenance plan should be incorporated, as appropriate, in the various technical manuals, logistic support documents, and product improvement programs. The appropriate DD Form 1423 sequence-number items for these manuals and other documents should have a statement in Block 16, "Remarks", that requires the incorporation of the suitable material from this maintenance plan into the manuals and other documents.

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8. APPROVAL LIMITATION:

9A. REFERENCES: AR 70-1, AR 70-60, AR 70-71, SPC 810, DI-R-1779, DI-R-1781, DI-R-1783

9B. MCSL NUMBER: AMSC#: A3647

10. PREPARATION INSTRUCTIONS:

10.1 General. The NBC Contamination Survivability Assurance Plan shall describe procedures, test methods, special test equipment, and data analysis methods that shall be required to ensure that the equipment/subsystem/system's NBC contamination survivability is maintained at an acceptable level during production of the equipment/subsystem/system. The assurance plan shall be based on data from the NBC Contamination Survivability Design Parameters Report (DI-R-1781), and shall be in accordance with the Government-approved NBC Contamination Survivability Test Plan (DI-R-1779). The assurance plan shall include, as a minimum, the following information:

10.2 Background.

(a) A discussion of how the proposed assurance plan assures the equipment/subsystem/system's NBC contamination survivability during production.

(b) Specific considerations made to exclude certain designs, piece parts or piece part technologies, components, materials, or processes, including the reason for these exclusions.

(c) A discussion of the most critical aspects of this maintenance plan, the consequences of alternative approaches considered, and the risks associated with the recommended approach.

10.3 Hardware Considerations. The identification of the assemblies, subassemblies, circuits, modules, components, piece parts, or materials that are critical to the equipment/subsystem/system's operation in an NBC contamination environment and the specific parameter values and qualities to be maintained for these items, with the drawings and the documentation where these items appear marked with a flag, HCI, for hardness critical items (alternative marking may be proposed, but must be approved by the procuring activity prior to use).

10.4 Operator's Procedures.

(a) The delineation of operator's procedures necessary before an NBC contamination event to achieve an acceptable response for the system/subsystem/equipment, considering deployment philosophy; protective procedures (such as orientation of the equipments, configuration of the various items of the equipment, subsystem, system) and devices (such as foxholes, canvas covers, shelters, etc.); and acquisition of storage of critical parts.

(b) The operator's procedures necessary after an NBC contamination/decontamination event, such as replacing components, modules, subassemblies, reloading logic data, greasing, oiling, etc.

10.5 Certification.

(a) NBC contamination survivability certification procedures shall include, but not limited to, a description of the facilities to be employed, special instrumentation, measurement techniques, calibration procedures, simulants for contaminants and decontaminants as required, test procedures, test methods and data analysis, and specifics of the schedule to be followed. The specifics of the schedule shall include the time after deployment before the initiation of the maintenance plan, the frequency of testing, the reporting schedule, and the timing of this certification schedule with respect to the normal maintenance schedule.

(b) These certification procedures shall include a listing of piece parts, materials, components, circuits, structures, subassemblies, assemblies, and systems to be tested with detailed information concerning tests and parameters to be measured; monitor points and rationale for choices; ambient conditions, modes of test sample operation and sample configurations, as appropriate, during the test with rationale; sample size; the number and kinds of Government-Furnished Equipment (GFE) required; the interface requirements or the interaction of subassemblies/subsystems with the rest of the system; and the data to be recorded.

(c) Acceptability criteria for the certification tests and remedial actions where the acceptability criteria are not met.

(d) The methodology for interpolation or extrapolation of test results to an assessment of how the system responds to the specified environments.

(e) The quantity and category of labor required to implement the certification procedures.

DATA ITEM DESCRIPTION # DI-R-1784

1. TITLE: NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) CONTAMINATION SURVIVABILITY FINAL REPORT

2. IDENTIFICATION NUMBER: ARMY, DI-R-1784

3. DESCRIPTION/PURPOSE:

   To document all phases of work performed in the NBC Contamination Survivability Program.

4. APPROVAL DATE: 15 JULY 1985

5. OFFICE OF PRIMARY RESPONSIBILITY: DELNV

6. DDC REQUIRED:

7. APPLICATION/INTERRELATIONSHIP:

   7.1 Application. When a solicitation or contract contains a requirement for NBC contamination survivability in the demonstration and validation phase and/or in the full-scale development phase, (RDTE categories 6.3 and 6.4 as defined in AR 70-1), this data item shall be listed on the Contract Data Requirements List (DD Form 1423) with delivery specified no later than 60 to 90 days prior to contract completion.

   7.2 The procuring activity shall have the option of specifying this data item in the appropriate statement of work (SOW) by reference and listing it on the DD Form 1423.

   7.3 This data item should be specified when the procuring activity has a need for an overview/summary of the NBC Contamination Survivability Program as applied to a specific equipment/subsystem/system. This data item may also be beneficial to contractors developing similar items of Army materiel, or for technology transfer in general.

   7.4 AR 70-71, Nuclear, Biological, and Chemical (NBC) Contamination Survivability of Army Materiel, contains the Army policy applicable to NBC survivability.

   7.5 In addition to the DIDs referenced in paragraph 10.1, this data item is also directly related to:

   DI-R-1781, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Design Parameters Report.

   DI-R-1780, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Test Report.

   DI-R-1783, Nuclear, Biological, and Chemical (NBC) Contamination Survivability Maintenance Plan.

   7.6 Director
   USA ERADCOM
   Night Vision & Electro-Optics Lab
   ATTN: DELNV-C/DM
   Fort Belvoir, Virginia 22060

8. APPROVAL LIMITATION:

9A. REFERENCES: AR 70-1, AR 70-71, DI-R-1778, DI-R-1779, DI-R-1782

9B. MCSL NUMBER: AMSC#: A3649

10. PREPARATION INSTRUCTIONS:

10.1 Contents. As a minimum, the final report shall contain the following:

(a) Legible updated copies of the final version of the NBC Contamination Survivability Program Plan (DI-R-1778) and the final version of the NBC Contamination Survivability Test Plan (DI-R-1779) prepared in accordance with the DD Form 1423. These shall not be copies of the original version of these documents.

(b) Detailed vulnerability analyses including transient and permanent effects analysis accomplished. These analyses shall include identification any vulnerabilities, the level at which they occur, and the protection designed into the equipment/subsystem/system to circumvent these vulnerabilities.

(c) Detailed results of all tests accomplished.

(d) Adjustments and/or corrections made to the NBC Contamination Survivability Assurance Plan (DI-R-1782) as a result of analyses/test results.

(e) Any other details and/or results pertinent to the overall NBC Contamination Survivability Program for the equipment/subsystem/system.

APPENDIX G

NBC CONTAMINATION SURVIVABILITY/NUCLEAR WEAPONS EFFECTS TEST FACILITIES

PREFACE

This listing of Nuclear, Biological, and Chemical (NBC) Contamination Survivability and Nuclear Weapons Effects (NWE) test facilities is for reference in the planning of medical materiel development projects within the U.S. Army Medical Materiel Development Activity (USAMMDA). It was also compiled to assist development contractors associated with USAMMDA. Some development contracts awarded by USAMMDA require vulnerability and survivability testing to be performed as a result of the applicability of AR 70-60 and AR 70-71. Contractors have reported difficulty in locating appropriate test facilities, and have sought USAMMDA assistance. This listing will provide a reliable source for this purpose and for other USAMMDA needs.

The content of the listing includes the:

1. Name and address of the facility;
2. Telephone numbers of points of contact for contracting and scheduling tests;
3. Types of testing accomplished;
4. Types and sizes of test chambers;
5. Categorization of NBC Warfare agents handled;
6. Characteristics of major test apparatus;
7. Special equipment and its principal characteristics; and
8. Capacity information, if available.

The listing is broken down into two parts, NBC Contamination Test Facilities (Section 1.0) and NWE Simulators (Section 2.0).

Concerning NBC contamination test facilities, the capability of handling toxic agents is described in terms of "all," "some," or "none;" and "neat" (full strength), "dilute," or in the form of "simulant" chemicals or biologicals. The term "all" should not be interpreted to include new toxic agents which are not well known. It is expected that telephone calls to the contact point will be used to verify capability in these cases and to clarify the term "some."

A comprehensive guide to nuclear weapons effects simulators may be found in DASIAC-SR-89-6 "Guide to Nuclear Weapons Effects Simulation Facilities and Techniques." This guide, prepared by K.F. Gould of Kaman Sciences Corporation, Tempo Division for the Defense Nuclear Agency (Contract No. DNA001-88-C-0025), contains a list of all types of simulators both existent and in construction/planning. Requests for this guide may be made through the Director, Defense Nuclear Agency, Washington, D.C. 20305-1000.

Size of test chambers is given for tentative selection of facilities only as there appear to be differences in what is considered the test chamber configuration. Accordingly, the dimensions applicable to the intended use should be obtained directly from the point of contact prior to scheduling.

Capacity information is included where available. These capacities are generally based on an 8-hour day. Most facilities could accept additional surge workload on an emergency basis, if overtime pay is reimbursed.

Table of Contents

SECTION 1.0

NBC CONTAMINATION TEST FACILITIES

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Allied/Bendix Environmental Systems Division 1400 Taylor Avenue Baltimore, MD 21284-9840
Points of contact:	(Scheduling) Mr. Vic Yates (301) 321-5200 (Contracts) Mr. Lou Hause (301) 321-5200

1. Types of testing: Chemical, Biological
2. Capability to handle CW agents: All

	a. Neat	Yes
	b. Dilute	Yes
	c. Simulants	Yes
3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	No
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Some
8.	Destructive materials	Yes

Special Equipment

Chemical Hoods 4 x 6 ft.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:

Artech Corp.
2901 Telestar Court
Falls Church, VA 22042

Points of contact:

(Scheduling) Henry Hahn (703) 560-3292
(Contracts) Henry Hahn (703) 560-3292

1. Types of testing: Chemical
2. Capability to handle CW agents: Some

	a. Neat	No
	b. Dilute	Yes
	c. Simulants	Yes
3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Special Equipment

8 Chemical Hoods

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: ASTRE Corporate Group
1130 E. Market Street
P.O. Box 5072
Charlottesville, VA 22905

Points of contact: (Scheduling) Roy Ackerman (804) 977-0425
(Contracts) Roy Ackerman (804) 977-0425

1. Types of testing: Chemical, Biological
2. Capability to handle CW agents: All
   - a. Neat — Yes
   - b. Dilute — Yes
   - c. Simulants — Yes
3. Equipment for neutron induced activity — No
4. Gas chromatography — Yes
5. Liquid chromatography — Yes
6. Spectrometric capabilities — Yes
7. Nondestructive materials testing — Yes
8. Destructive materials — Yes

Testing Chambers

TYPE	SIZE
Chambers	(Smallest) 750 ML (Largest) 52 Liters

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Battelle Memorial Institute 505-T King Street Columbus, Ohio 43201
	Battelle/Columbus (614) 879-5118 Battelle/Northwest (509) 375-2121
Points of contact	(Scheduling) Dr. Joiner * (Contracts)

1. Types of testing: Chemical
2. Capability to handle CW agents: Yes

	a. Neat	Yes
	b. Dilute	Yes
	c. Simulants	Yes
3.	Equipment for neutron induced activity	*
4.	Gas chromatography	*
5.	Liquid chromatography	*
6.	Spectrometric capabilities	*
7.	Nondestructive materials testing	*
8.	Destructive materials	*

* Would not give necessary information. Referred to CRDEC at Aberdeen.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	CALSPAN, Corp. Box 400 Buffalo, NY 14225
Points of contact:	(Scheduling) Elizabeth Wilkinson (716) 632-7500 (Contracts) Richard Leous (716) 631-6832

1. Types of testing: Chemical
2. Capability to handle CW agents: All

a.	Neat	Yes
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	No
7.	Nondestructive materials testing	No
8.	Destructive materials	No

Special Equipment

(4) Chemical Surety Hoods
(1) Chemical Surety Chamber (13 ft x 20 ft x 40 ft)

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Chemical Compounding Corp.
680 Elton Avenue
Riverhead, NY 11901

Points of contact: (Scheduling) Dan Kohn * (516) 727-8600
(Contracts) Dan Kohn * (516) 727-8600

1. Types of testing: Chemical
2. Capability to handle CW agents:
   a. Neat — Yes
   b. Dilute — Yes
   c. Simulants — Yes
3. Equipment for neutron induced activity *
4. Gas chromatography *
5. Liquid chromatography *
6. Spectrometric capabilities *
7. Nondestructive materials testing *
8. Destructive materials *

* Would not give necessary information over the telephone.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: GEOMET Technologies, Inc.
20251 Century Boulevard
Germantown, MD 20874

Points of contact: (Scheduling) Dr. Sibbet (301) 428-9898
(Contracts) Dr. Sibbet (301) 428-9898

1. Types of testing: Chemical, Biological
2. Capability to handle CW agents: All
   a. Neat — Yes
   b. Dilute — Yes
   c. Simulants — Yes
3. Equipment for neutron induced activity — No
4. Gas chromatography — Yes
5. Liquid chromatography — No
6. Spectrometric capabilities — Yes
7. Nondestructive materials testing — No
8. Destructive materials — Yes

Special Equipment:	Size	Characteristics
(1) Environmental Chamber	32 cubic feet	-40°F - +200°F
(5) Chemical Surety Hoods		

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Illinois Institute of Technology (IIT) Research Institute 10 W. 35th Street Chicago, IL 60616
Points of contact	(Scheduling) Dr. Dave Clark (312) 567-4284 (Contracts) Theodore Plonis (312) 567-4170

1. Types of testing: Chemical, Biological
2. Capability to handle CW agents: All

a.	Neat	Yes
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Testing Chambers

Type	Size
Fume Hoods	36" x 30" x 30" (smallest) 4' x 4' x 8' (largest)

Other Info

Capability to synthesize agents

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Lab for Energy Related Health Research (LEHR) University of California Davis, CA 95616
Points of contact:	(Scheduling) Dr. Marvin Goldman (916) 752-1341 (Contracts) Dr. Marvin Goldman (916) 752-1341

1. Types of testing: Nuclear, Biological, Chemical

2.	Capability to handle CW agents: Some	
	a. Neat	No
	b. Dilute	Yes
	c. Simulants	Yes
3.	Equipment for neutron induced activity	Yes
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Special Equipment

Chemical Surety Hoods
Chemical Fume Hoods

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Los Alamos National Lab P.O. Box 1663 Los Alamos, NM 87545
Points of contact:	(Scheduling) Dr. Petersen (505) 667-1853 (Contracts) Perry Studt (505) 667-4494

1. Types of testing: Nuclear, Chemical, Biological
2. Capability to handle CW agents: All

	a. Neat	Yes
	b. Dilute	Yes
	c. Simulants	Yes
3.	Equipment for neutron induced activity	Yes
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Testing Chambers

Type	Size
Glove Boxes	10 cubic feet (smallest) 20 cubic feet (largest)

Special Equipment

Pulse X-Ray
Nuclear Reactors

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Mine Safety Appliances Co.
P.O. Box 429
Pittsburgh, PA 15230

Points of contact: (Scheduling) Dr. J.W. Mauspellen (412) 538-3510, Ext. 147
(Contracts) Ralph Hiltz (412) 538-3510, Ext. 150

1. Types of testing: Chemical

2. Capability to handle CW agents: All

a.	Neat	Yes
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Some
8.	Destructive materials	Yes

Testing Chambers

Type	Size
Hood Chamber	1 cubic ft. (smallest)
Environmental Chamber	4300 cubic ft. (largest)

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Massachusetts Institute of Technology
Room 20, Bldg. 238
Cambridge, MA 02139

Points of contact: (Scheduling) Richard Chamberlin (617) 253-5360
(Contracts) Richard Chamberlin (617) 253-5360

1. Types of testing: Nuclear, Chemical, Biological

2. Capability to handle CW agents: All

a.	Neat	Yes
b.	Dilute	No
c.	Simulants	No

3.	Equipment for neutron induced activity	No
4.	Gas chromatography	No
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Note: Individual was referred to EER by another company which could not perform chemical testing. Unusual to have someone in Cambridge who can perform chemical testing.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Mid-West Research Institute 425 Volter Boulevard Kansas City, MO 64110
Points of contact	(Scheduling) Mr. Bill Jacobs (816) 753-7600, Ext. 539 (Contracts) Mr. Tony Katsanoness (816) 753-7600 Ext. 334

1. Types of testing: Biological, Chemical
2. Capability to handle CW agents: All
   a. Neat — Yes
   b. Dilute — Yes
   c. Simulants — No
3. Equipment for neutron induced activity — Yes
4. Gas chromatography — Yes
5. Liquid chromatography — Yes
6. Spectrometric capabilities — Yes
7. Nondestructive materials testing — Yes
8. Destructive materials — Yes

Special Equipment

(15) Chemical Surety Hoods, Numerous Other Equipment

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: National Center for Toxicological Studies
Jefferson, AK 72079

Points of contact: (Scheduling) Pete Atwood (501) 541-4278
(Contracts) Pete Atwood (501) 541-4278

1. Types of testing: Chemical, Biological

2. Capability to handle CW agents: All

a.	Neat	Yes
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	No
8.	Destructive materials	Yes

Special Equipment

Fume Hoods

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	S-cubed P.O. Box 1620 La Jolla, CA 92038
Points of contact	(Scheduling) Bill Heyl (619) 453-0060 (Contracts) Joy Walters (619) 453-0060

1. Types of testing: Nuclear
2. Capability to handle CW agents: None

	a. Neat	No
	b. Dilute	No
	c. Simulants	No
3.	Equipment for neutron induced activity	Yes
4.	Gas chromatography	No
5.	Liquid chromatography	No
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Special Equipment

2 Chemical Hoods

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Southern Research Institute
2000 9th Avenue South
Birmingham, AL 35255

Points of contact: (Scheduling) Gary Sides (205) 323-6592
Ext. 2409
(Contracts) Carolyn Philips (205) 323-6592
Ext. 2465

1. Types of testing: Chemical
2. Capability to handle CW agents: All

a.	Neat	Yes
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Special Equipment

Chemical Surety Hoods

4 ft wide, 30 in. deep
2 ft high working space

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Southwest Research Institute 6220 Culebra Road San Antonio, TX 78284
Points of contact:	(Scheduling) Mr. Herb Peel (512) 522-2692 (Scheduling) Mr. Sam McFarland (512) 522-2030 (Contracts) Mr. Alex Garza (512) 522-2238

1. Types of testing: Nuclear, Biological, Chemical

2. Capability to handle CW agents: Some

a.	Neat	No
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	Yes
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials	Yes

Testing Chambers

Type	Size
Environmental Chamber	4 cubic ft. (smallest) 12 cubic ft. (largest)

Special Equipment

Chemical Fume Hoods
Chemical Surety Hoods

<u>NBC CONTAMINATION TEST FACILITIES</u>

<u>TEST FACILITY</u>:	Army Materiel Test & Eval. Dir. White Sands Missile Range, NM
Points of contact:	Chemistry Laboratory Autovon 258-1764 Comm. (505) 678-1764

1. Types of testing: Chemical, Nuclear

2. Capability to handle CW agents: None

	a. Neat	<u>No</u>
	b. Dilute	<u>No</u>
	c. Simulants	<u>Yes</u>
3.	Equipment for neutron induced activity	<u>Yes</u>
4.	Gas chromatography	<u>Yes</u>
5.	Liquid chromatography	<u>No</u>
6.	Spectrometric capabilities	<u>Yes</u>
7.	Nondestructive materials testing	<u>No</u>
8.	Destructive materials testing	<u>Yes</u>

Lab provides centralized chemical service support to include materials testing, chemical analysis of degenerated components for the identification, and determination of failure mechanisms.

<u>Special Equipment</u>

Gas Chromatographs
Spectrophotometers
Emission Spectrograph
Polarograph
X-Ray Diffraction Unit
X-Ray Spectrograph
Mass Spectrometer
Neutron Activation Analysis System

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Chemical Analysis Laboratory
U.S. Army Armament, Munitions, & Chemical Command
Rock Island, IL

Points of contact: (Scheduling) Autovon 793-6294
(Contracts) Comm. (309) 794-6294

1. Types of testing: Chemical Analysis Lab.
2. Capability to handle CW agents: None
   a. Neat — No
   b. Dilute — No
   c. Simulants — Yes
3. Equipment for neutron induced activity — No
4. Gas chromatography — Yes
5. Liquid chromatography — No
6. Spectrometric capabilities — Yes
7. Nondestructive materials testing — No
8. Destructive materials testing — Yes

Analysis capability exists for metallic and nonmetallic materials. Equipment includes a scanning electron microscope, atomic absorption spectrometer, x-ray spectrometer, infrared spectrometer, gas chromatograph, and optical emission spectrometer.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Chemical Laboratory Division
Dugway Proving Grounds, Dugway, UT

Points of contact (Scheduling) Autovon 789-5137
(Contracts) Comm. (801) 522-5137

1. Types of testing: Chemical

2. Capability to handle CW agents: All

    a. Neat — Yes

    b. Dilute — Yes

    c. Simulants — Yes

3. Equipment for neutron induced activity — No

4. Gas chromatography — Yes

5. Liquid chromatography — Yes

6. Spectrometric capabilities — Yes

7. Nondestructive materials testing — Yes

8. Destructive materials testing — Yes

Testing includes chemical offensive and defensive systems and materiel;
Equipment is available for a wide range of laboratory-scale tests required in the engineering evaluation program and evaluation of materiel to agent penetration.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Chemical Laboratory Aberdeen Proving Ground, MD 21010	
Points of contact	(Scheduling) (Contracts)	Autovon 584-3143 Comm. (301) 671-3143

1. Types of testing: Chemical Agent and Screening Agent Dissemination Testing
2. Capability to handle CW agents: All
   a. Neat — Yes
   b. Dilute — Yes
   c. Simulants — Yes
3. Equipment for neutron induced activity — No
4. Gas chromatography — Yes
5. Liquid chromatography — Yes
6. Spectrometric capabilities — Yes
7. Nondestructive materials testing — Yes (see below)
8. Destructive materials testing — Yes

Testing Chambers

Type	Size	Characteristics
Cylindrical Chamber 3/4" steel	30 ft.(D) x 19 ft.(H)	Fans, decontamination and rinse systems.
Cylindrical Chamber 3/4" steel	10 ft.(D) x 12 ft.(H)	

Special Equipment

Metallography, radiography, ultra-sonics, eddy current, liquid penetrant.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Chemical Systems Laboratory Research Division Aberdeen Proving Ground, MD 21010
Points of contact	(Scheduling) Autovon 584-3727 (Contracts) Comm. (301) 671-3727

1. Types of testing:
2. Capability to handle CW agents: None
   a. Neat — No
   b. Dilute — No
   c. Simulants — Yes
3. Equipment for neutron induced activity — No
4. Gas chromatography — Yes
5. Liquid chromatography — No
6. Spectrometric capabilities — Yes
7. Nondestructive materials testing — Yes
8. Destructive materials testing — Yes

Testing Chambers

Type	Size	Characteristics
All-weather toxic	32 x 9 x 8 ft.	Temp Range - 70-100°F
Hot chamber	24 x 15 x 10 ft.	Temp Range - 65 to 140°F Hum. 5 to 98%

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Defensive Test Chamber Facility U.S. Army Test and Eval. Comd. Dugway Proving Ground, UT
Points of contact	(Scheduling) Autovon 789-5276 (Contracts) Comm. (801) 522-5276

1. Types of testing: Chemical/Biological Agent and simulant testing in MIL-STD-810D environmental conditions

2. Capability to handle CW agents: All

   a. Neat — Yes

   b. Dilute — Yes

   c. Simulants — Yes

3. Equipment for neutron induced activity — No

4. Gas chromatography — Yes

5. Liquid chromatography — No

6. Spectrometric capabilities — Yes

7. Nondestructive materials testing — Yes

8. Destructive materials testing — Yes

Testing Chambers

Type	Size	Characteristics
MIL-STD-810D modular chambers with ambient air sterility.	20 ft. high x 30 x 50 ft.	Control and operating instruments in separately controlled to maintain operational

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Environmental and Life Sciences Lab Facility Environmental and Life Sciences Division Dugway Proving Ground, Dugway, UT
Points of contact	Autovon 789-5173 Comm. (801) 522-5173

1. Types of testing: Biological
2. Capability to handle CW agents: Some

a.	Neat	No
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	No
8.	Destructive materials testing	Yes

Testing Chambers

Type	Size	Characteristics
Static aerosol (Reynier) sterilization; temp above freezing	600 liters	Temp range - 30°C to i.e., 121°C. Relative humidities 5 - 95% at temp.

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Gas Chromatograph/Mass Spectrometry Lab.,
U.S. Armament, Munitions, and Chemical Command
Aberdeen Proving Ground, MD 21010

Points of contact: (Scheduling) Autovon 584-2560
(Contracts) Comm. (301) 671-2560

1. Types of testing: Chemical Analysis of Toxic Materials
2. Capability to handle CW agents: All
   a. Neat — Yes
   b. Dilute — Yes
   c. Simulants — Yes
3. Equipment for neutron induced activity — No
4. Gas chromatography — Yes
5. Liquid chromatography — Yes
6. Spectrometric capabilities — Yes
7. Nondestructive materials testing — No
8. Destructive materials testing — No

Testing Chambers

Type	Characteristics
Lethal agent hoods and exhausts	Inlets for gas, liquids and solids

Special Equipment

2 Hewlett-Packard Gas Chromatograph/ Mass Spectrometers	1000,	Resolution up to
Mass Spectrometers	Mass Range - 10 to	1000 AMU, Scan speed variable from 0.33 to 900 AMU/sec, Up to 4 ions

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY:	Measurement and Analysis Division, U.S. Army Test and Evaluation Command Aberdeen Proving Ground, MD
Points of contact:	(Scheduling) Chemical Laboratory - Bob Durgin Autovon 283-2868 Comm. (301) 278-2868

1. Types of testing: Chemical
2. Capability to handle CW agents: Toxics but not CW agents

	a. Neat	No
	b. Dilute	No
	c. Simulants	Yes
3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	No
8.	Destructive materials testing	No

The chemistry facility is equipped with analytical chemistry instrumentation and standard chemical apparatus. The facility is capable of performing a wide variety of chemically-oriented test in quality assurance, as well as chemical and physical analysis of organic and inorganic items.

Primarily used in the analysis of metals and elements higher than atomic number 11.

Special Equipment

Jarrel-Ash Model 865A Spectrophotometer
X-ray Diffraction Emission Unit, 1 KEV to 60 KEV

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Nuclear Magnetic Resonance Spectroscopy Lab.
Aberdeen Proving Ground, MD 21010

Points of contact: (Scheduling) Autovon 584-3863
(Contracts) Comm. (301) 671-3863

1.	Types of testing: Chemical Analysis	
2.	Capability to handle CW agents: All	
	a. Neat	Yes
	b. Dilute	Yes
	c. Simulants	Yes
3.	Equipment for Neutron Induced Activity	No
4.	Gas chromatography	No
5.	Liquid chromatography	No
6.	Spectrometric capabilities	Yes (See below)
7.	Nondestructive materials testing	No
8.	Destructive materials testing	No

Special Equipment

5-Varian Nuclear Magnetic Resonance Spectrometers

1-Varian Electron Spin Resonance Spectrometer

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Organic Materials Laboratory
U.S. Army Materials and Mechanics Res. Ctr.
Watertown, MA 02172

Points of contact: (Scheduling) Autovon 955-3141
(Contracts) Comm. (617) 923-3141

1. Types of testing: Chemical Testing through spectrometry, gas chromatography, and electron microscopy.

2. Capability to handle CW agents: None

a.	Neat	No
b.	Dilute	No
c.	Simulants	No
3.	Equipment for neutron induced activity	No
4.	Gas chromatography	Yes
5.	Liquid chromatography	No
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	No
8.	Destructive materials testing	Yes

Special Equipment	Characteristics
Perkin-Elmer Nuclear Magnetic Resonance Gas Chromatograph/Mass Spectrometer Digital Fourier Transform Infrared Spectrometer AMR Scanning Electron Microscope RCA Transmission Electron Microscope Picker X-ray Diffractometer Energy Dispersive X-ray Spectrometer ESCA/Auger/SIMS Spectrometer for surface and thin-film analysis	-100 to +150 deg C. Finnigan 10 to 1000 amu

NBC CONTAMINATION TEST FACILITIES

TEST FACILITY: Radiochemical Research Laboratory
Aberdeen Proving Ground, MD 21010

Points of contact: (Scheduling) Autovon 584-3171
(Contracts) Comm. (301) 671-3171

1. Types of testing: Scintillation counting, radiochromatography, radiation dosimetry, and gamma ray spectroscopy.

2. Capability to handle CW agents: All

a.	Neat	Yes
b.	Dilute	Yes
c.	Simulants	Yes

3.	Equipment for neutron induced activity	Yes
4.	Gas chromatography	Yes
5.	Liquid chromatography	Yes
6.	Spectrometric capabilities	Yes
7.	Nondestructive materials testing	Yes
8.	Destructive materials testing	Yes

Testing Chambers

1500 sq. ft. in
3 buildings

Special Equipment

Closed circuit television system for monitoring.

14 MeV Neutron Generator
High-intensity cobalt-
60 source

SECTION 2.0

NUCLEAR WEAPONS EFFECTS (NWE) TEST FACILITIES

Reference DASIAC-SR-89-6, "Guide to Nuclear Weapons Effects Simulation Facilities and Techniques," 28 February 1989. Requests may be referred to Director, Defense Nuclear Agency, Washington, D.C. 20305-1000.